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ABSTRACT

The major papers presented at the 1971 conference of the South Australian Science Teachers Association are included in this pamphlet. Scientists from industry, research institutions, and the police forensic laboratory, and practicing teachers presented papers which included descriptions of modern scientific techniques, discussions of the role of science education in meeting some societal problems, and a series of teaching techniques. The titles of the major papers are: "Education for Our Students in the 80's," "The Australian Science Education Project," "The Work of the Practising Scientist," "Forensic Science," and "Science and Culture." The descriptions of classroom techniques include projection techniques, teaching the topic "machines," demonstrations in fluid dynamics, and a series of demonstrations for chemical reactions illustrating the formation of new substances, energy changes, reversibility, reaction rates, stoichiometry, and catalysis; most of the demonstrations are suitable for use at the junior high school level. (AL)

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SASTA JOURNAL REPORT ON THE

CONFERENCE AND SCIENCE FAIR

SALISBURY TEACHERS COLLEGE, JULY 1971

SE 013 428

In drawing up their programme the organizers of the 1971 SASTA Conference were keenly aware that the conference should be both meaningful to teachers and relevant to society's present problems and present and future needs. In other words the conference was to have a message.

The increasing friction between science and society, the pressures imposed on science and technology to prevent a threatened catastrophe, and the complete re-thinking of science education being currently undertaken were key factors in influencing the SASTA Conference Committee to choose as their theme *Science and Society*.

Thus it was that a broad spectrum of speakers was sought – University dons (with, nevertheless, controversial points of view), a practising scientist, a technologist, a science educationist and a humanist – all to provide a balanced view of both *Science* and *Society*.

Other highlights of the conference included:

- Seven 'Here's How I Do It' segments.
- The Science Fair of student exhibits.
- A display of apparatus and books from a range of science firms.
- The annual dinner and the presentation of the 1970 AIDA Award.

This report contains the major part of the material presented at the conference. We regret the fact that, for various reasons, the paper delivered by Dr Coulter and the segments of Leo Davis and Michael Hewitson could not be included. Roger Cooper's 'Here's How' can be found in *SASTA Journal 712*, and a report of the AIDA medal presentation was given in the previous (September) journal, as was the Science Fair.

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W P ROGERS and P S DAVIS, UNIVERSITY OF ADELAIDE

EDUCATION FOR OUR STUDENTS IN THE 80's

Peter S Davis received a bachelor's degree in Applied Biology at the Sydney Technical College. This he followed up with a master's degree in Radiochemistry at the University of New South Wales and a Ph.D at the University of Adelaide. He has worked with the CSIRO at Cronulla as an oceanographer, and with The Australian Atomic Energy Commission where he studied the movement of radioactive fission products through food chains. He currently holds the appointment of Reader in Medical Biology at the University of Adelaide, where his research interests are in the fields of trace metal metabolism and plant lectins.

He has published scientific work in a wide range of fields, and is an ardent advocate of an interdisciplinary approach to the solution of environmental problems.

William P Rogers is a professor at the Waite Agricultural Research Institute. He has the degrees of Ph.D and D.Sc, and was educated at the University of Western Australia, the London School of Hygiene and Tropical Medicine, and the University of Cambridge. He is a Fellow of the Australian Academy of Science and a member of the WHO Committee in parasitic diseases.

Professor Rogers likes teaching and research work. Outside his work his chief interests are food and wine and the breeding of Hereford cattle.

Do we have to face up to a colossal failure in education? I think the answer to this is in the affirmative because most people do not get an education which prepares them to recognize or think rationally and constructively about the problems which mankind must face in the next few decades. These problems must be solved; they threaten not only our organized community life but also the very survival of the human species. (There is no cosmic law which says that man is unique among the species of the planet and must survive come what may. We will survive and retain an acceptable quality of life only if we as a species prove fit to handle the challenges.) I will briefly mention some of these problems, and discuss why education, and especially education in science, is needed for their solution.

The Major Problems

These problems are with us now; and if they are not solved quickly the results will be catastrophic. They may be seen in many guises – 'Bombs, Babies and Bulldozers' is perhaps the simplest – and they are all interconnected.

'Bombs': Human Aggression and the Threat of War

The cost of the cold war is about two hundred thousand million dollars per annum ($US 2 x 10^{11} pa) - something like 6% of the world's gross national product – and requires the skills of more than half of the world's scientists, engineers and technicians.[1,2] The Vietnam conflict is costing not only many lives; it has also caused a vast destruction of the environment. Chemical defoliants used at thirteen times the recommended concentrations have covered 12% of South Vietnam, and nearly four million acres of crops have been destroyed.[3]

The 'hot war' is the real threat to the survival of the species. Scientists who are aware of the nature of new weapons in the military pipeline and the consequences of deployment of these weapons believe, almost unanimously, that if the super powers continue their nuclear arms race a nuclear disaster is sooner or later inevitable.[4] The multiple independently targeted re-entry vehicles (fourteen warheads to a single ICBM) make it possible for a single submarine to fire one hundred and sixty warheads.[5] The present deployment of nuclear missiles by the US and USSR is sufficient, if directed at the fifty largest cities on each side, for an 'overkill ratio' of about fifteen for the US and eight for Russia, and provides more than ten tons equivalent of TNT for every man, woman and child on this globe.[6]

The points which are of special interest to science teachers can be listed.

1 No scientific or technological solution to the threat of war is available.[7]

2 Solutions to this problem will require a better understanding of the nature of human aggression. Much has been written about this problem,[8] but few experimental human studies have been undertaken.

3 Seen in a biological and evolutionary context much of our instinct of aggression is now an anachronism, no longer of survival value as it was to primitive man; but in this age of lethal weapons, lethal motor cars and a complex 'global village' it is a positive danger. We must ask ourselves whether our education system minimises aggression and finds socially harmless outlets for it, or whether, through emphasis on the examination system, organized

team sports, the fostering of competition and the praising of academic success, it is in fact maintaining and even raising the level of aggression in students.

4 Educators have a responsibility to show their students that, whether at a personal level or an international level, the traditional technique of resolving a conflict – the 'shootout' – is no longer useful. Violence is no longer an acceptable solution to human conflict; other means must be developed if we are to survive. Moreover, war is economically unnecessary. The weapons industry, given the will, could be turned off without economic injury,[1] and there is no need to compete on military terms for resources. Synthetic man-made wealth, which is increasingly supplementing natural wealth, is not an object for competition; it is something that all men can obtain and use.[9]

'Babies': The Population Crisis

The rapid rise in man's numbers poses a threat to the species because it requires a more and more ruthless use of the earth's limited resources and because it results in an increasing gap, about 4% pa,[10] between the rich and the poor countries of the world; 'the rich get richer and the poor have babies'.

In a graphic account of the situation prompted by the *Apollo* flights to the moon Anthony Tucker[11] wrote of that other spaceship – earth. He described it as having 3600 million passengers, 500 million first class, the rest third class, undernourished and deprived. 'It has no commander, no trained crew and no flight plan. It possesses strictly limited life-support systems, limited energy capability, and limited material resources.' In spite of this he goes on to say, 'The spacecraft on this flight is expected to accommodate 8000 extra passengers every hour while also providing more of everything for everyone on board.'

The bare facts of the population dilemma are simple: it took mankind at least 250,000 years to reach his first thousand million, 100 years to reach the second, and little more than 30 years to reach the third. At present the doubling time of the world's population is 37 years, and it seems likely that world population will reach the six thousand million mark before the end of the century. When we look at population growth rate in terms of affluence we see that, although the world growth rate is 1.9% pa, the 75% of the world's population living in Africa, Asia and Latin America is growing at more than twice the rate (2.1%) of the privileged 25% of the world's people who live in North America, Europe, USSR and Australasia (0.9%).[12]

In the past population size was determined by pestilence, famine and the prevailing fertility rate – factors then outside man's mastery. But man can now control these factors, and has at his disposal the means to control population growth. He can choose to use them intelligently and reproduce at a rate commensurate with the resources available, or he can avoid rational decision and let population levels be controlled by catastrophe.

'Bulldozers': The Environmental Crisis

In the last decade we have become aware that we are using up the earth's resources and producing waste products and toxic substances at such a rate as to effect a general deterioration of the environment. The problem is intimately related to the growing population of consumers and the rapidly increasing standard of living of the world's developed countries which have adopted economic and technical policies without thought to their ecological implications.

The environmental crisis is seen not only in the physical symptoms of smog, polluted rivers, dying lakes and disappearing wildlife species but also in the changing patterns in society. More people have been urbanised in the past ten years than perhaps in all the rest of history, and we are now confronted with problems of urban sprawl, clogged up traffic arteries, and increasing violence, alienation and loneliness in big cities which adversely affect mental health. One third of all hospital beds in Perth (for which figures are available) are occupied by patients with psychiatric disorders. The suicide rate in Australia has increased almost 50% in the past decade from 10.3 per 100,000 of population in 1955 to 14.9 per 100,000 of population in 1965.[13] Most of this increase, incidentally, is due to self-poisoning with medically prescribed drugs.

These, in outline, are the major problems of the world in which our students are growing up. In the context of these problems much of our present education seems irrelevant.

Can Education Solve These Problems?

Even in Australia our capacity to educate people is strained. The population is increasing through natural growth and immigration at a faster rate than we can supply schools and teachers. Is it reasonable to suggest, then, that the scope of education be further broadened? To me it seems there is no other satisfactory course. First of all the major problems facing society, such as the ones I have referred to, must be acknowledged as existing – and here teachers have a great responsibility because many people who have a good understanding of these problems often speak of them in such a sensational or hopeless manner that consideration seems worthless. The confusion which results from many religious teachings, economic misunderstandings, political evasions and short-sightedness must be countered. This won't be achieved simply by teaching more and more different facts. It requires an education which gives insight into how facts are obtained and evaluated and how valid conclusions of general application may be drawn.

Why a Scientific Education?

The major problems I have referred to have all become acute in recent times as a result of outstanding successes of science and technology. It is tempting, therefore, to take the attitude that as science has got us into the mess, the same science can find the solutions. However, there is a type of problem which cannot be solved by the conventional methods of science. May[14] made this clear when he pointed out that the triumphs of science and technology have all been concerned with solving *linear* problems – problems, that is, in which a very complicated whole can be (conceptually or actually) disassembled, studied simple piece by simple piece, and the complex whole then reassembled and understood as no more than the linear sum of its parts. It is this approach which has led to modern developments in nuclear energy, space travel, computer technology and molecular biology because the analytical and empirical scientific method is one of the most powerful tools ever devised by man for dealing with problems of this type.

However, there are problems of another type: non-linear problems. These cannot be understood by assembling the component pieces because the components are continuously interacting with each other in a complex fashion so that, in a sense, the whole is greater than the parts. Many social problems are like this and require new methods for their solution. This is one of the reasons why the social sciences and inter-disciplinary studies are attracting more attention and are now recognized as the major area of challenge for scientific endeavour. May also pointed out that there is a group of problems which admit of no technical solution – that is, problems which cannot be solved by a change in scientific or technological capability alone but which also require a change in human values or ideas of morality. Problems in this category obviously include overpopulation and war.[15]

If science has these limitations why, then, is education in science important? All students need to learn something of the method of approach to problem-solving used in scientific work because more rational, unemotional thought about our present problems is needed. We need to pass from precedent-based to knowledge-based judgements. We must solve the dilemma of a growing demand for a widespread sharing in decision-making on the one hand and the increasing need for scientific and technological expertise to inform our judgements on the other.[16] So far education has largely failed to give most students a feeling for the way science investigates a subject, the way scientists subject their observational data to critical evaluation before reaching conclusions, and the way they make use of controls in the experimental situation. Few people are trained to draw only those conclusions which the data warrant, as is evident by the success of much present-day advertising; and yet I believe that this type of logical and critical thinking can be taught to children from an early age, and should be one of the prime goals of educators.

Pragmatic Aspects of Educational Needs

All people should have some up-to-date factual knowledge of the world they live in and about themselves. It is often argued that the increasing burden of scientific fact, doubling every ten years,[17] makes this impossible. But all these facts don't have to be taught; the more fact we have the clearer the theory and the easier it is to select the significant evidence for or against basic concepts. There seems to me to be no reason why education cannot deal with the veracity gap – that the world is not what we like to think it is. But this must be largely a matter of adult education which builds on a basis of rational thought and intellectual method of enquiry acquired as children.

Human biology – especially factors affecting the size of the human population – man's place in nature and the strengthening of the instinctive inhibitions of killing one's own species should also be approached pragmatically. But all this should be interwoven with an understanding of what, for want of a better word, might be called the 'philosophical' basis of our problems.

The 'Philosophical' View

1 The Purpose of Education

Modern education both at school and in the university is offered and pursued largely as a means for personal advancement, for a better job or for more influence within the system in which we live. It does not seriously provide an evaluation or criticism of that system even in the most liberal of countries. This should be changed. Education must be provided and sought primarily as a benefit for the species; our fitness to survive depends on this. This is not to advocate an education for the glorification of the state; on the contrary, it opposes nationalism and advances the virtues of man as a species.

It has been said, 'When the real danger of fall-out became known the test-ban treaty became a reality.'[18] This is how education should function!

2 Man's Attitude to the Environment

A basic aim of education must be to correct man's misapprehension of his place in nature. The concepts that human reproduction is necessarily a good thing, that man is above nature and can use it to his own ends, are religious and especially Christian convictions. It has been argued that this philosophy is the basic cause of man's ruthless attitude in the exploitation of his environment. Either the Christian church must discard these views and lead the world to recognize

this necessity, or the pressure of circumstances will force man to throw them overboard, and perhaps with them a great deal of valuable Christian ethic.[19]

Whatever the origin of our attitude to the environment it is clear that it must be changed. Education must be directed towards bringing this about. Without such a change in attitude the need for a 'looped' economy[22] and the necessity for considering the ecological (as well as social and cultural) effects of large scale technological manipulation of nature lose much of their force.

The Clash of Subcultures

Education has failed to bridge the gaps between the dominant subcultures – scientific, religious, military and political – of our day. This clash is not appreciated by scientists generally. The science subculture is small, probably less than 2% even among highly educated people. In contrast the religious, political and military subcultures are much larger. Scientists take it for granted that they win the clashes with other subcultures: with the churches on questions of evolution or with the communist party over genetics. Because of our isolation we think we have won these battles, but it is not necessarily so; witness the popularity of mystical cults, astrology and so on. And this really is not surprising. How many people really understand what are the basic features of the science subculture, how the subculture differs from others, why it is important? It is important because scientists form one group which is accustomed to serve the common interests of mankind whatever their national and ideological commitment.[20] It is the first truly common enterprise of man, and it gives an alternative for the competition for natural reserves by providing an alternative way of obtaining wealth.[21]

Though the science subculture is important it must be emphasized that it is not *all* important; it must be combined with the other humane subcultures to provide the essential climate for human progress. Nevertheless it is the distinctions between the science subculture and the dominating political and military subcultures which are most disturbing. 'There is an increasing unhappiness in the scientific community with secrecy, with the sort of deceptions that international politics seem to demand and with the military ethic.'[22] The chief characters of the science subculture are as follows.

The Habit of Truth

Bronowski said, 'Science is the creation of concepts and their exploration in the facts. It has no other test of the concept than its emprical truth to fact. Truth is the drive at the centre of science; it must have the habit of truth, not as a dogma but as a process.' This 'habit of truth' of the scientist is embraced not because he is more virtuous as a person but because truth is a basic feature of the system he follows and is essential for its success. This contrasts with situations in political, business or military subcultures where suppression or distortion of truth can often serve useful ends.

The Abhorrence of Secrecy

One of the rewards of being a scientist is the sense of being a member of a group which has no boundaries of race, sex, religion or time. The binding interest is a search for truth; the test is the scrutiny of results and ideas by one's fellows. This requires communication and an openness of discussion. This ideal of the science subculture cannot be reached in secrecy. Must secrecy be such a dominating feature of other subcultures?

Curiosity

In most subcultures curiosity is frowned upon – 'curiosity killed the cat' – but it is a necessary feature within the science subculture.

The Critical View of Authority: Orthodoxy With Dissent

Scientific advance is by disproof of hypotheses. The findings and ideas of even the most distinguished scientist must always be subject to test and revision. This continuous dissent from orthodoxy is an accepted feature of the science subculture. In contrast, criticism of traditional military and political ethics, or even the objective study of the non-traditional, can be 'subversive'!

Advancement Through Failure

The science subculture is the only one in which advance is the result of legitimised failure. What is right is found by discovering what is wrong. This is the greatest moral contribution of the science subculture. It has '. . . removed the main obstacle to the growth of human knowledge which is the refusal to learn from failure because of the threat which this poses to our identity as a person'.[22] The scientist is pleased when his views are disproved because this advances science; the good hypothesis, even when shown to be wrong, is respected, and the scientist who proposes it is not regarded as a failure. The scientist whose hypothesis is disproved may be annoyed personally, but this does not prevent him from recognizing the importance of disproof in the advancement of science.

How Science Might be Taught

Ecological Framework

It seems reasonable to suggest that science, and perhaps other subjects as well, should be taught within a framework of ecology. The word itself, coming from the Greek, *eikos*, a house, reminds us that our house is the spaceship earth. Education then should lead to an examination of what are the earth's resources and what is the extent of these resources. At a very early age

children can grasp the distinction between renewable and non-renewable resources. They can be led on, as schooling develops, to an understanding of such concepts as the optimum use rate of renewable resources and the need for recycling non-renewable resources. They will see that the variety of living species on earth is a non-renewable resource, and will come to appreciate why it is in man's interest to preserve and safeguard the richness and beauty of this variety.[23]

This framework of thinking which shows, as an ideal, man living in harmony with nature rather than as the master and exploiter of nature could have profound effects. Although the initiative for such an approach must come from the science teacher its effects will spill over into economics, history, geography, social studies and the humanities generally. Its effect could be to help our students revaluate the widely held concepts that continuous economic expansion and increased productivity are good things; that nationalism and national sovereignty will always promote human welfare; that the right to reproduce is an inalienable right of a couple, no matter what the need of society; and that war and the threat of war be legitimate instruments of national policy.

The Green Bay Experiment

The idea of using human ecology as a unifying concept for an education system has already been proposed and used[24] in an experiment in university education. The concept of a 'Survival U' was put forward by Fischer[24] as a university where all work could be focused on a single unifying idea: the study of human ecology and the building of an environment in which our species might be able to survive.

In 1969 a cluster of four campuses located in and around Green Bay, Wisconsin, part of the much troubled University of Wisconsin system, was given over to a new experiment in university education. (The university, at present catering for three thousand students, will eventually expand enrolment to twenty thousand.)

At Green Bay the innovations have been radical in purpose, in internal structure and in methods of teaching. The focus of all studies is on the single overriding subject of ecology, and a deliberate effort has been made to break down the tight isolation of the traditional disciplines such as economics, political science, English literature, chemistry, sociology and the rest which has imposed such a rigid pattern of departmental organization on the conventional universities. At this university ecology is taken to deal with the environment we live in, both physical and social. Fischer puts the case strongly: 'This is *the* cardinal subject. For unless we learn, pretty fast, to live on the earth's thin crust without destroying it, all the other subjects – from philosophy to twelve tone music – will not only be irrelevant, they will simply disappear, along with *Homo* non-*sapiens*.' It is in this sense that ecology embraces all other subjects, and is not simply one academic study among others. At Green Bay it is consciously used as an approach to all learning and as a framework for organising every field of study.

The introduction of the new system at Green Bay was difficult. The sacrosanct departmental system had to be overcome, and staff young and daring enough to take part in an experiment which ignores the safe, worn ruts of academic advancement had to be recruited. And, most difficult of all, the concept had to be accepted that true scholarship could be involved in dealing with complex and broad problems, and was not to be found only in the pursuit in depth of tiny areas of existing disciplines.

The Green Bay experiment is worth watching. Its success or failure has not yet been determined, but it must be acknowledged as a thoughtful and courageous attempt of a university to discern and respond to the urgent needs of the society which supports it. Australian universities have no less obligation to their society, and it is to be hoped that they do not turn their backs on this challenge.

From Research Papers

An interesting strategy of science education which avoids the factual survey type of instruction has been devised and used by Epstein at Brandeis University.[25] It is a development of the case-study method. The teacher selects six to ten original research papers within his own special field of interest – papers that tell a connected and developing story. These are read by the students and then discussed in class, where first of all word meanings, unfamiliar terms and the nature of the experimental design and techniques are explained. Then the possible interpretations of the data and proposals for further experiments are developed out of class discussion. Emphasis is placed on what the scientist has done to obtain his results rather than on the facts, and the student is encouraged to follow the intellectual and creative processes of the research as experienced by the scientist.

By the use of this approach the nature of the scientific method as a creative use of man's intellect is demonstrated, and the power of the scientific method as a problem-solving tool can be appreciated by the student. Moreover the scientist is seen as a person with his own set of motivations, fears, abilities and areas of knowledge and ignorance. Thus questions often arise in the class discussion that cannot be answered from the papers being studied. If the author is living the class may wish to write to him for the extra background or personal information they need for their understanding. I think most scientists would readily respond to such a request.

This teaching method has been used with success at a number of universities in the US, particularly with

first year students who are intending to major in the humanities. The possibility of using this approach at secondary schools is one that I think would be exciting to explore.

Conclusions

Our prime goal must be human survival; not merely the physical survival of man as a biological species but the survival of the individual man within a society which recognizes his human-ness – his aesthetic, moral and spiritual dimensions.

Environmental science is the science of man's survival. It deals not only with the evaluation and intelligent use of physical resources but is also concerned with the difficult notion of 'quality of life'.

The challenge for us as teachers is to provide an education which has these twin aspects of man's survival as its central and unifying theme.

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THE AUSTRALIAN SCIENCE EDUCATION PROJECT

Gregor A Ramsey has a science degree in Physics and Chemistry from Adelaide University and a Ph.D degree in Science Education and Curriculum Development from Ohio State University.

He was Special Senior Master in Chemistry at Woodville High School for four years, and so has first-hand knowledge of the difficulties facing science teachers. In his present position as Assistant Director of ASEP (Service Division) he is responsible for organizing the technical production of materials, the Project's teacher education programme and evaluation, and the provision of resources for the developers of the materials.

The Australian Science Education Project began as a functioning entity on 1st October 1969 when the Director, Mr H O Howard, and the two Assistant Directors, Mr Les Dale and I, met together for the first time at the Australian Council for Educational Research in Hawthorn, Victoria.

In the ensuing twenty one month period we have grown from a group of three to a fully functioning organization with a staff of almost fifty. Our headquarters are a large, old house in Toorak, the former Victorian Technical Teachers College.

Four Development Area Specialists and an Area Specialist in Evaluation effectively began duty with the Project in January 1970. This was also the month in which the Project held its Guidelines Conference, when scientists, science educators and teachers came togather to establish guidelines for the Project. Whilst these guidelines were not spelled out in detail two things emerged which made it necessary for us to embark on an extensive period of planning. The first was that the Project, now that it was to be truly national, should not be merely an extension of the Junior Secondary Science Project. It should determine its own philosophy and approach relevant to the national scene. The second was that the kind of science taught should put emphasis upon the developmental needs of children rather than the content of science.

It was these guidelines, and the principles laid down by the Commonwealth and the States when they established the Project, that formed the base for our 'position' statements. Summaries of our positions are elaborated in our Newsletters.

A problem not envisaged when the Project was originally planned was that of recruiting suitably qualified staff. This difficulty is still with us, and it is now unlikely, for financial reasons, that we will have the full complement of Materials Development Officers as set down in the original proposals to the Commonwealth Government.

This staffing leeway has been made up, to some extent, by utilizing working parties in the various states and encouraging development external to the Project. For example, a South Australian working party headed by Mr Peter Sandery has developed a unit, 'Light and Images'. They are at present working on a second unit with an anthropological bias called 'The Human Unit'. This external development has been possible only because we have taken care to document our positions and aims. If this had not been done it is doubtful whether the work of external developers could have dovetailed easily into work being done at the Project.

The first four units were available for trial in February-March this year, and I think you will find, when you look at them, that we have learned a lot since then. For example, even though we were producing only about 800 copies free for trials schools the quality of reproduction in the early units was just too poor for effective evaluation. (It is interesting to note that many evaluators focus on the quality of reproduction or on our ability to proof-read, rather than on the quality of the ideas expressed!) To improve quality we purchased a new plate-making machine and offset duplicator, the total cost of which was almost $10,000. The first unit to show most of the benefits of the new equipment is 'Pigments and Acidity', which I think you will agree, in terms of production, is a great improvement on the unit, 'Messengers'.

As a Project we at last see ourselves as a credible organization. We are gaining confidence that we can fulfil the task confronting us, and believe that we can be a force for the improvement of science education in Australia. These feelings have been strengthened by the recent decision of the Australian Education Council, comprising the various Ministers and Directors-General of Education, that management of the Project should be vested solely in our national Committee of Management. The Australian Council for Educational Research, which had managed the Project prior to the decision, was simply to service our accounting needs.

This decision means that we are now a completely new and autonomous structure on the Australian education scene, free to pursue our purposes as we see fit within the limits of time and finance available.

One very interesting thing about the Project is that everyone from the switch-girl to the area specialists and directors had to learn a new job when they came to the Project. We discovered very quickly that even though someone had good academic qualifications, or had a good teaching record, it did not necessarily mean that the person could develop curriculum materials. Many people had to find out by trial and error what their role should be. We have found that it takes about six months after leaving the classroom for a person to become a fully functioning member of Project staff.

This task of learning to develop curriculum materials is larger than it may appear at first sight. I had known for a long time that there was a special branch of science called school science which uses, as its source of ideas, the findings of real science of some decades ago. I had not realized until I came to the Project that not only is there school science but there is also South Australian school science, Western Australian school science, and so on! To see teachers come to the Project from all over Australia, first to have to shed their state science notions and then to reform their ideas to design a science which contributes to the growth and development of children, was a tremendous though sometimes painful experience.

In this report I am assuming that you are well aware of the purposes of the Project—that is, its aims and the method of how we go about producing and evaluating units. What I intend doing is to give the present state of development of units, and then I will use the unit 'Plants' as a type example.

Before I become specific I would like to touch on three points which often seem to come up for discussion when teachers come together to talk about our Project. The first relates to the way in which we intend to integrate the content of science. We integrate science content by developing materials which relate the child to his environment by having him explore:

1 himself as an individual
2 himself as a group member
3 the extensions of his physical and mental self
4 the technology of his environment
5 the natural environment

The integration of the various content areas occurs naturally, and the words, 'physics', 'chemistry', etc are rarely heard at the Project.

The second common area of discussion relates to the way in which our materials suit various ability levels. Traditionally education systems have grouped students on an age-grade basis, and then within an age-grade they are grouped on some ability criterion. The age-grade basis did not seem a satisfactory one on which to write materials because there is usually much greater variation in ability within any grade level than there is between grades.

We turned therefore to some researched criteria of intellectual development, rather than the arbitrary grade or age-level divisions that have been traditional. We identified three stages of intellectual development for junior secondary students based on the work of Piaget, and the materials developed had to suit the students at these stages of development.

Stage 1 materials are for those students at a concrete stage in their intellectual development. The units for students at this stage explore the environment through direct *concrete* experience so that there is a direct and immediate relationship between the experience and the idea being developed. Student activity in trial situations provides the major source of motivation and experience.

Stage 2 materials are for those students who are in a *transition* stage in their intellectual development. Units for this stage will be largely activity based, but will provide students with an opportunity to explore more formal or abstract modes of thinking. Students at this stage cannot take too much formal thinking, but can be encouraged to explore more formal or logical mental operations from a sound base of concrete experience.

Stage 3 materials are for those students who have reached a *formal* stage in most of their intellectual processes. These students can manipulate ideas mentally without recourse to concrete experience, and can handle more abstract thought. Second-hand data may be used, and manipulation of ideas without recourse to the physical reality is possible.

The approximate proportion of students at any age at the three stages of development is shown in Fig 1.

At present the Project aims at developing 17-18 Stage 1 units, 14-17 Stage 2 units and 9-11 Stage 3 units. To permit teachers maximum flexibility in the selection of their own programmes there will be no mandatory links between Stage 1 units, although there will be some links between Stage 1 units and Stage 2 and Stage 3 units. Fig 2 will give some indication of possible links.

The third area of discussion is the way in which we intend to allow for the individual differences of children. Differences in reading ability are to be allowed for to some extent by writing the materials at least one grade level below the most likely grade for which they are to be used. Thus Stage 1 materials are written at about Grade 5-6 level. Differences in interest are to be accommodated for by a system of options. All students do the core of a unit, unless they can demonstrate that they already have the required knowledge. About one fifth to one quarter of the

Fig 1

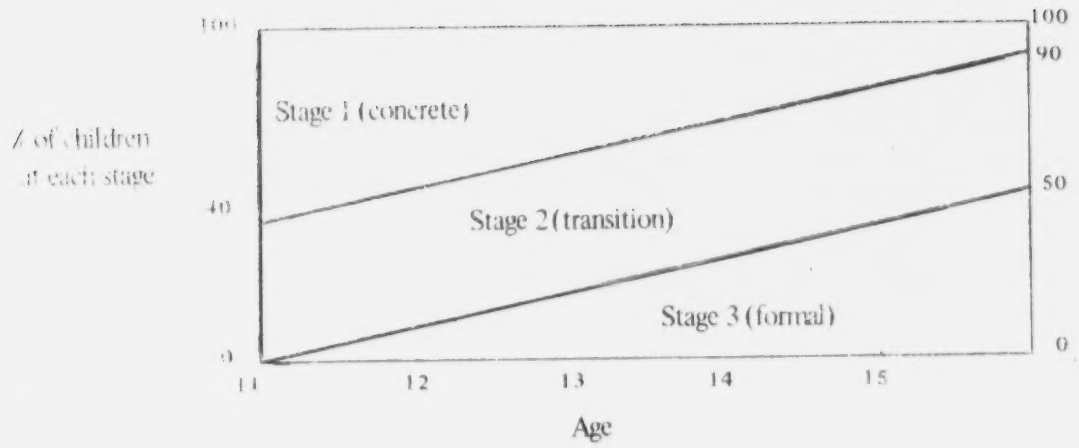
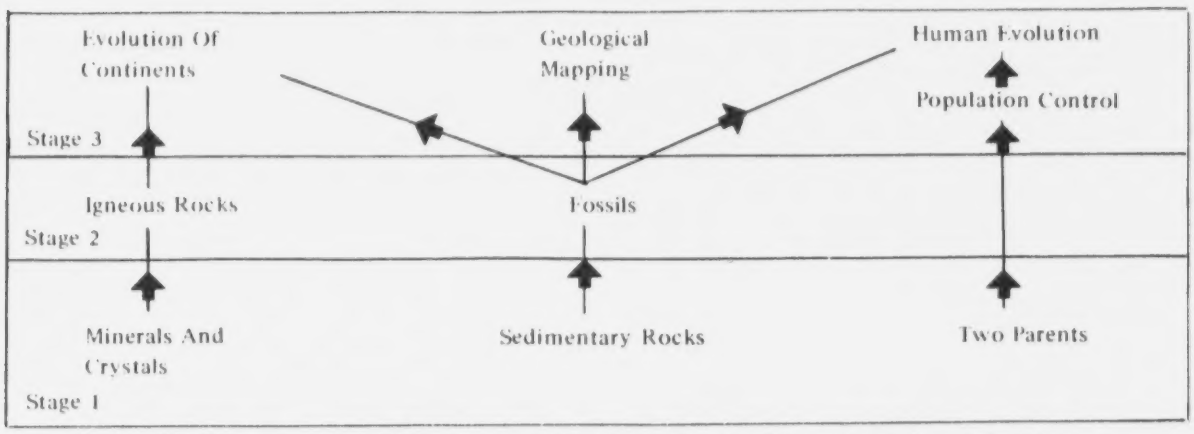


Fig 2



Note: No Stage 1 unit is linked to another Stage 1 unit. Most Stage 2 and 3 units are interlinked. It is intended that during the development of each unit attention will be given to ways of reducing the numbers of units linked in any one sequence while still preserving a development of knowledge and abilities from earlier to later stages.

total time devoted to the unit is spent on the core. The remaining time is spent on the options, and it will be a very good student who completes more than half of them. Another major difference among students is the rate at which they work. The materials are designed to have students work at a rate that suits them best, and so different students will be doing different things in the classroom at the same time.

All of these ideas are documented in our various position documents, which at last count number about sixty. To quote from a letter we received at the Project after a teacher from interstate visited us a few days ago:

At first I thought that the continual reference to ASEP aims, Piaget levels, cognitive and affective outcomes and so on, was all part of your vernacular, and may not go very much further than that. On closer reading this basing of ASEP materials on sound learning theory is taken seriously in all stages of their development.

Our position statements may be imprecise and lack clarity, but we do believe that it is impossible to develop valid curriculum material unless you attempt to state what you intend to do, and then try to establish how well your intentions are being attained in practice.

The general state of development of units at the Project may be summarized thus:

First specifications written	55
Second specifications written	31
Manuscripts completed	16
Units produced	9
Units tried or on first trial	8
Units being rewritten	4

The Project will have sufficient time and finances to develop about 40 of the 55 units specified at the first stage. In addition it will develop some service type units like 'Using a Microscope' or 'Preparing for a Field Trip' which will provide useful preparatory activities.

One of the strong points of the ASEP unit system is that units may be added to or withdrawn from the total pool of units available to the teacher without

making a whole text obsolete. Also, even after the Project terminates other groups may develop units based (say) on ASEP first specifications which could be used as part of a programme for schools.

The following lists give the titles of units and the stage of development of each (at the time of writing):

Completed First Trials and Being Rewritten

Working in the Laboratory	Stage 1
The World of the Soil	1
Mice and Men	1
Messengers	1

On Trial in Schools

Microbes	2
Charge!	2
Plants	2
Pigments and Acidity	1
Using a Microscope (Service unit)	

Ready for First Trials

Sticking Together	2
Preparatory Graphing, Calculating Skills (Service unit)	

Production Stage

Minerals and Crystals	1
Signals Without Words	1
Males and Females	1

Editing Stage

Life in Freshwater	2
Populations	3
Energy and Change	1
Light Forms Images	1

Writing Stage

Fossils	2
Pushes and Pulls	1
Genetics	3
Controls	3
Getting Into Gear	2
Australian Landscapes	2
Rocks Formed from Sediments	1
Where Humans Came From	3
Made to Measure	1
Little Boxes	1
Traffic	3
Cells	1

Writing Stage (Outside Working Parties)

Water (NSW)	1
The Human Unit (SA)	3
Pollution (RACI)	
Petroleum (Petroleum Information Service)	
Inside the Earth (Vic)	
Getting to Know ASEP (Goulburn TC)	

The first four units commenced first trial in March 1971. Four other units have been on trial this term, and somewhere between six and eight will have their first trial in the third term.

ASEP first-trial classes, apart from one in Canberra, are all close to ASEP headquarters. Each unit is tried with eight classes, and we have 53 schools in reasonably close proximity to ASEP for trialling – 20 state high schools, 8 state technical schools, 18 independent schools and 7 independent Catholic schools – providing a total of 116 classes.

The second trials of units will commence in schools throughout Australia in February 1972. The maximum number of classes in Australia to trial any given unit is 25. This is the maximum number we can afford to service.

It is important to realize that ASEP terminates in December 1973 so that, in effect, our Project will not exist when a maximum effort will be needed for teacher education workshops and the like to introduce teachers to the materials.

We believe that organizations such as the state Science Teachers Associations, working through our established State Advisory Committee, will have an increasing role to play in the evaluation of our materials and in their eventual introduction. We believe strongly in the autonomy of the states to decide for themselves what they want to do with ASEP materials. For this reason we look on the second trial of materials to be very much a State Advisory Committee trial.

We are proposing the establishing of a trials co-ordinator who will co-ordinate the second trials for the State Advisory Committee and the Project. Each unit will be tried by a team of three in SA, (four in NSW and Vic), headed by a team leader who is a volunteer. The other members of the team should be representative of science teachers in the state. (See Fig 3) These proposals could be expanded in much greater detail; however, the trials co-ordinator may wish to do that in a future *SASTA Journal.*

The proposed timetable for second trials is:

September 1971
: Trials co-ordinators from all states meet together at Glenbervie, Toorak.

October 1971
: Selection of team leaders.

November 1971–February 1972
: Three-day workshops in the various states for trials teachers (18 from SA).

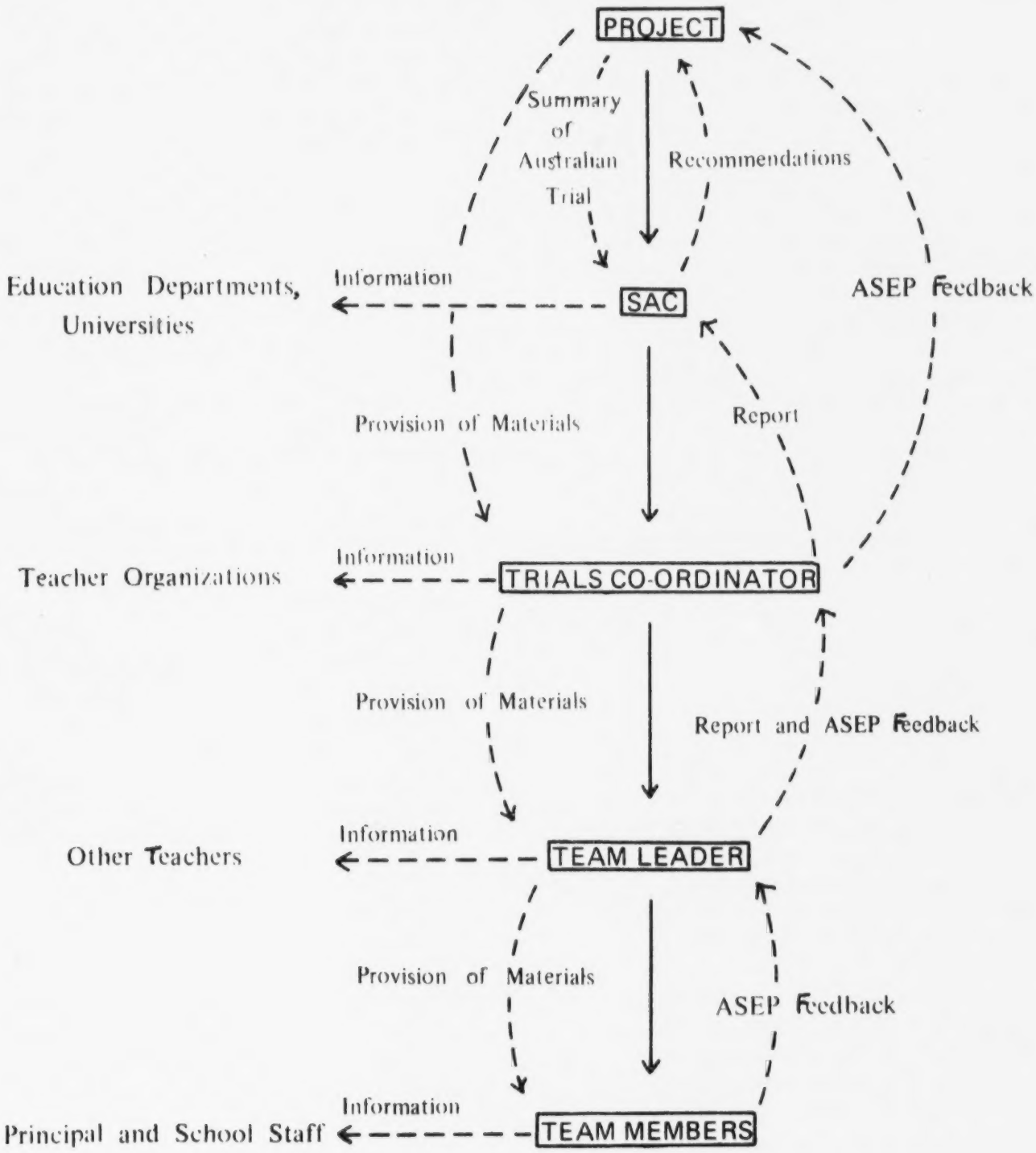
February–July 1972
: Seven Stage 1 and two Stage 2 units become available for trial.

July–August 1972
: Second round of three-day workshops for new group of trials teachers.

July–November 1972
: Seven Stage 1, two Stage 2 and four Stage 3 units become available for trial.

Fig 3

LINES OF COMMUNICATION FOR SECOND TRIALS



October 1972–February 1973
Third round of workshops (if necessary).
February–April 1973
Five Stage 1, eleven Stage 2 and five Stage 3 units become available.

After the feedback from second trials has been summarized the units will be rewritten for final publication, which will occur over the period 1972-3-4. All units should be available to schools by February 1975, although the first should be available commercially in the beginning of 1973.

I shall now describe one unit on trial in schools and another in the planning stage. The first is the unit 'Plants'.

This unit is an investigation of the diversity of plant types and the way in which the variety of plants changes from one locality to another. Students are encouraged to grow their own plants at school and note the stages of development. They will observe the different groups of plants in the booklet 'How and Where They Grow', and these observations will provide a basis for later investigations.

We expect that teachers or students (preferably the latter) will make a selection from among the eleven investigations described in the second booklet, 'Investigations'. The materials prepared for this unit could be used in a variety of ways, and the teacher should adopt the method he considers to be best.

Here follows a summary of the contents of this unit, with suggested time allocations.

HOW AND WHERE THEY GROW

1 Introduction (1 period)
The ASEP film 'Looking at Plants', could be shown and discussed. Alternatively, students may look at plants in the school ground. This is a completely unstructured excursion.

2 Growing Plants From Seeds (1 period to begin; observations to continue for 3 weeks)
Seeds are planted and looked after by the students. Observations on stages of development are made. The progress is recorded graphically and with diagrams.

3 Excursion (2 periods plus 1 period for follow up; 1 period may also be necessary for preparation)
Students look at the diversity of plants and plant habitats. Observation tables and distribution maps are made.

4 Differences Between Plants (1 period)
Students observe different plants and record their observations in a table.

5 Where Plants Live (1 period)
Students look at slides of different environments, describe them and name the plants they can see. The idea of adaptation to environment is established and then discussed.

INVESTIGATIONS
There are 11 optional activities included here.

Non Flowering Plants

1 Sea-shore Plants (2 periods on sea-shore plus 1 period in science room)
Students visit a sea-shore and make observations about seaweeds. A seaweed collection is made, and red and brown pigments are removed from the seaweeds.

2 What Makes Water Green?
Students use microscopes to see the algae, and then try to remove the green colour by adding small crustaceans. Finally they look at the contents of an aquarium or a muddy pond.

3 Moulds and Mushrooms (2 periods; observations to continue for 2-3 weeks)
Students can grow fungi, look at a mushroom and try to grow mushrooms. They are asked to read about harmful and beneficial fungi.

4 Two Plants in One (2 periods)
Students observe where lichens are growing and the effect of lichen acids on rock. They also cut thick sections of lichens. Advice is given about collecting lichens.

5 Mini-plants (2 periods)
Mosses are collected and a single plant is looked at closely. Students investigate the question, 'Can mosses live without water or light?'

6 Plants With Fronds (2 periods)
Through the use of a hygrometer, thermometer and light meter students compare the environment of a fern with a nearby sunny environment.

Flowering Plants

7 Monocots and Dicots (1-2 periods)
Flowering plants are classified into monocotyledons and dicotyledons.

8 A Colourful World (1 period)
Students observe the diversity in the structure of flowers.

9 Plants We Eat (1 period)
Students observe a variety of plant foods and decide which plant structure the foods represent.

10 A Cereal Story (2 periods)
The test for starch is established; then the students use this to show that cereals contain starch. Students also grow cereals.

11 Timber (2 periods)
The properties of wood are investigated. Students begin by looking at growth rings.

The total unit consists of three student booklets, work sheets, answer sheets, a teachers guide, a set of 20 slides of plants for individual use and a 16-minute introductory film.

In contrast to the 'Plants' unit the unit 'Australian Landscapes' will consist mainly of an extensive teachers guide, with slide sets for student use. There will be little student material other than the slide sets and question sheets. We agree that our materials to date have relied heavily on the written word. In this unit we hope to branch away from that trend. Something like 120 different slides for the unit are planned, and it is hoped to encourage the teachers to build on these by adding their own slides.

To conclude then. There have been criticisms of the Project in terms of slowness in production and woolliness in approach. These criticisms are a result of poor communication between teachers and the Project because they are not criticisms we receive from persons visiting the Project, whether they be teachers or persons from education institutions or visitors from other Projects or persons who have had close contact with the Project.

We hope lines of communication can improve with the commencement of second trials. Science teachers associations are important links in this communication chain. Our State Advisory Committees are seeing their role more clearly at a state level.

We would like to see SASTA increasingly involved in the evaluation of our materials, and we would welcome your proposals both in the area of internal (SA) development of materials and in the trialling of existing materials in specific situations relevant to your state's needs. Up to now too much communication has been from the Project outward. We would like to receive more inwards to the Project from science teachers in the field. I know the State Advisory Committees will be involving more of you in an armchair evaluation of our units. This we find very helpful. If you are asked to be a team leader or to participate in a trial I hope you will agree to be in it. South Australia has had greater curriculum activity in science than any other state, and that is why particular comment from this state is valuable. Another reason is the almost total commitment to small scale techniques which is not so in any other state.

ASEP could be the springboard for something good or it could be a damp squib. Which it is will depend on how effectively we can provide a common point of reference for science education in Australia. We are gaining increasing interstate co-operation, and this is something we must foster if only for the national economies it affords.

We do not have the complete answer to problems in science education. No one will ever have that. I do hope, however, that the Project will offer you some interesting possibilities that you may wish to try.

H A d'ASSUMPCAO, WEAPONS RESEARCH ESTABLISHMENT

THE WORK OF THE PRACTISING SCIENTIST

Henry D'Assumpcao received a Graduate Bachelor of Engineering with First Class Honours in 1956 at the University of Adelaide, and obtained his Master of Engineering in 1962 at the same institution. He is currently Principal Research Scientist in charge of a group at WRE (Salisbury), and is personally engaged in underwater detection signal processing and oceanography.

In essence I suppose the work of scientists hasn't really changed in several centuries. It has always consisted of making some observation about nature, devising some theory to explain the phenomenon, using the theory to predict what would happen under a different set of conditions, and then planning and carrying out an experiment to confirm the theory. If necessary the theory is scrapped or refined in the light of the new data.

Of course it is often not possible for one scientist to do all this. A Tycho Brahe might make observations about the planets, but we have to wait for an Isaac Newton to produce the broad and sweeping unifying theory to explain all the observations. Some scientists are good at collecting data in a methodical and reliable manner, but are unable to explain the results theoretically. Others might be quite hopeless at anything practical, but possess the creativity and imagination to make the intellectual leap to produce that simple theory which explains it all. And, of course, we have the whole spectrum between these two extremes.

One of the cardinal sins that a scientist can commit is to draw too hasty and generalized a conclusion from a poor and limited set of observations. The field of science today is extremely wide, embracing very many disciplines, and I am personally involved in only a small part of one narrow field of science. Therefore, rather than attempt to talk about the work of scientists in general, I shall tell you something of the work that my colleagues and I are engaged upon. From this account you will, I hope, derive a picture of the work of at least some practising scientists.

My group is concerned with problems of underwater detection. It has been said that the only frontiers of the world left unexplored are the upper atmosphere, Antarctica and the oceans. Some of us at the Weapons Research Establishment are engaged in a small way in trying to understand a little more about some of the properties of the seas.

The main properties of the oceans are familar to all. If you were to go down in the deep ocean you would, of course, taste the salt in the water. While descending you might next observe that it quickly gets dark and cold, and that the pressures are intense. But even though you are cold and in the dark and being crushed by intolerable pressures you might be surprised to note that there is a lot of noise underwater. These simple observations are sufficient to explain those properties of the sea that concern us.

Because of the presence of dissolved salts electromagnetic energy is rapidly absorbed; this explains why it is so dark underwater.

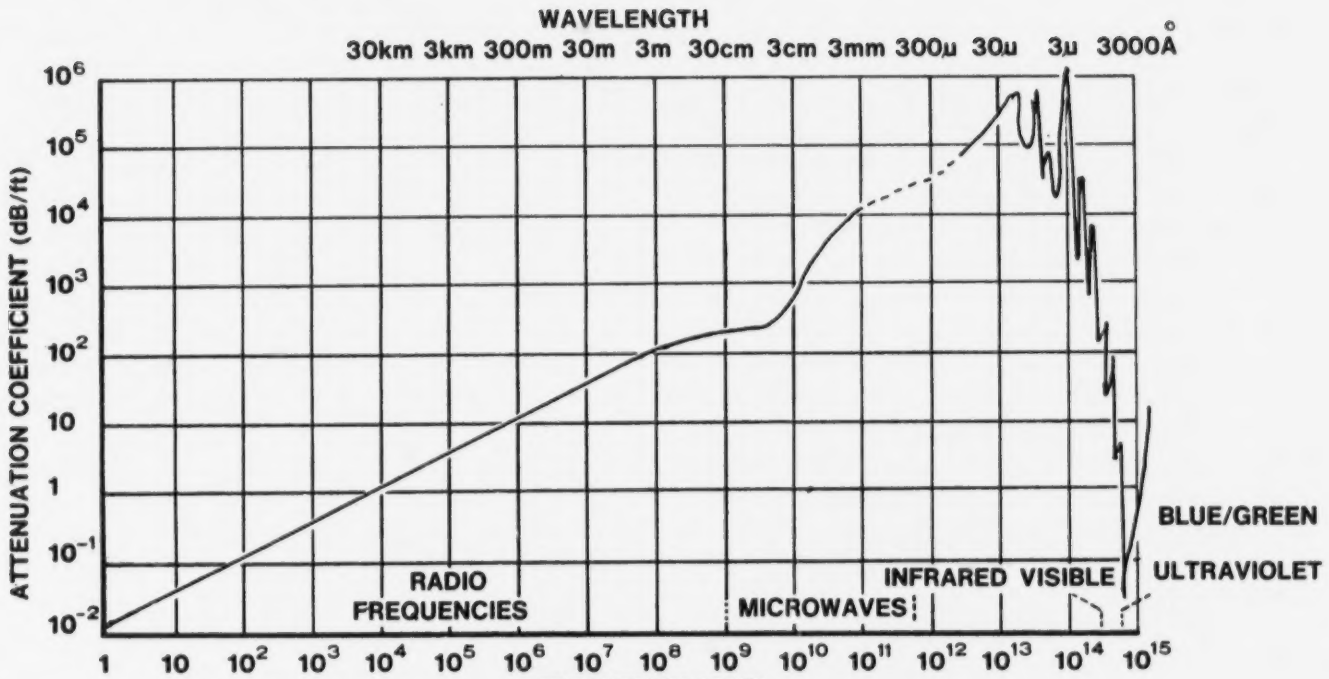
Fig 1 shows a graph of the attenuation of electromagnetic waves in sea-water, plotted as a function of frequency, with attenuation in decibels per foot. The curve shows that, except for a 'window' in the blue-green region of the visible spectrum, light is reduced in intensity many million times after propagating only one foot. Even light energy in the blue-green region can propagate only a few thousand feet before becoming vanishingly weak. Radio waves, too, suffer severe losses. So we may conclude that electromagnetic energy would not be very effective for underwater communication.

However, one form of energy that does propagate well underwater is sound. Under ideal conditions a modest bang underwater has been received several thousand miles away (and several hours later). Fish, of course, have known about this for years, and it is not uncommon to find fish whose sense of hearing is far more highly developed than their eyesight.

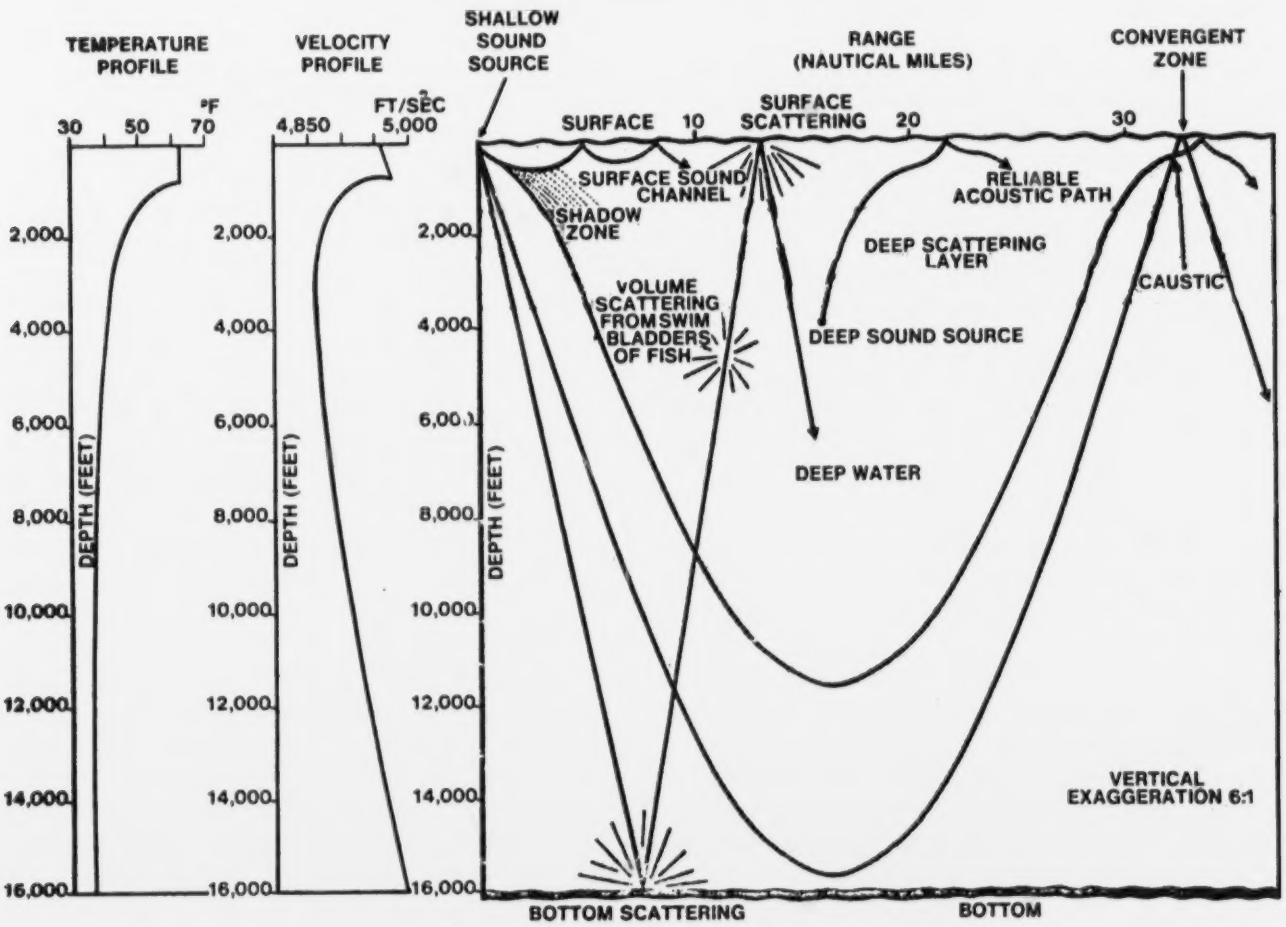
Unfortunately, even though sound can propagate over long distances it does not travel in straight lines. Sound rays are refracted if the velocity of sound changes, and this velocity—close to 5000 feet per second—is affected by temperature, salinity and pressure.

Fig 2 shows a 'typical' profile of temperature and velocity plotted against depth—if, indeed, anything about the ocean can be called typical. Salinity has been assumed constant, and would therefore not cause a bending of sound rays. Near the ocean surface the action of wind and waves causes mixing, and there is a layer of sensibly constant temperature. In this region only pressure changes, and the effect of this is to cause the velocity of sound to increase with depth. Below this mixed layer the temperature drops sharply, causing the velocity of sound to drop also. At great depths the temperature levels off to about 0°C, and pressure again takes over, causing the velocity of sound to increase. The net effect of all this is the velocity profile shown. The effect of this variation in velocity profile is to cause sound rays to bend in a complicated way. If a noise is made near the surface some rays skip along under the surface and are trapped in the so-called Surface Sound Channel. Other rays penetrate the layer, and are bent first down and then up to be focused in an annulus some 30 miles away; they are then reflected

Fig 1



ATTENUATION OF ELECTROMAGNETIC RADIATION BY SEA WATER



PROPAGATION AND SCATTERING OF UNDERWATER SOUND

Fig 2

off the surface and reappear at 60 miles, 90 miles, and so on.

Sound travelling along a steep path strikes the ocean bottom, and is partially transmitted into the bottom and partially reflected and scattered. There are regions to which sound can propagate and be heard clearly, and others–called 'shadow zones'–where it cannot.

But this is a simplified picture of the ocean. In practice surface mixing is neither complete nor uniform. Some fish possess swim bladders (which are pockets of gas used to maintain neutral buoyancy), and these both scatter and absorb sound. The bottom is never flat, and often possesses curious and unpredictable properties. Sea surface waves scatter sound energy. Temperature inhomogeneities, salinity variations and air bubbles further complicate the situation. Sound usually arrives at a receiver by a multiplicity of paths, and there are interference effects.

If we wish to listen to weak sounds we would be limited by the many noises in the sea. Breaking waves are the cause of one principal source of noise. Fish can be a problem as they produce a variety of grunts, groans and squeals. In some regions of volcanic activity seismic rumblings can be heard. And then we have noises made by man, for noise pollution extends underwater as well.

One of the reasons why so little is known about the ocean is that the sea is a very hostile environment. One has to travel out to the particular ocean site, and, whether this is done by ship or plane, it is expensive. Instruments must be robust and reliable; they are costly and all to easily lost at sea.

We have used a wide variety of instruments to measure ocean parameters. These range from the old Nansen bottle–essentially unchanged for half a century–which measures temperature and pressure and takes a sample of water from the depths, to modern instruments which may be dropped from an aircraft and send the data back by radio. To receive sound we use a hydrophone–the underwater equivalent of a microphone. Wave heights are measured using a wave pole–a long vertical buoy floating at the mean water level and supporting a thin insulated wire whose capacitance changes as the waves rise and fall.

Because sea experiments are so involved and expensive one tries to get as much as possible from each trip. Many hours of records are taken; hundreds of samples of water are brought back for analysis; instruments are carefully calibrated before and after each experiment. The mass of data is carefully sifted and analysed to extract meaningful information from which conclusions can be drawn. Was that bump on the curve due to an instrumentation fault or was it a real phenomenon in the ocean? It is too late now to repeat the experiment–the opportunity might never arise to go back to the same site, and in any case conditions would be different the next time. If someone was sea-sick and neglected to record some parameter–or recorded it incorrectly–the value of the experiment could be significantly affected. Then one has to draw some conclusions from the results. Does the data fit existing theory, or does one have to refine the theory? What further work is needed to resolve doubts? Data collected in an exercise lasting a few weeks can easily keep a team of analysts busy for many months.

What sort of qualities do we seek in a scientist for this kind of work? Obviously there is a requirement for a good grounding in physics. For the research scientist a solid background in mathematics is mandatory, and I would venture to guess that there would be very few fields today in which a research scientist can get far without fairly advanced mathematics. Some familiarity with computer programming is usually desirable because the sheer complexity of many problems makes a numerical approach necessary. However, there is a danger in what has been called 'computer intoxication'–an obsession with the machine itself instead of the problem which it should be used to help solve. There is sometimes a temptation to tackle a problem to get a specific answer in a particular situation by use of a computer, when the application of a little analytical thought might yield a general solution and provide a far deeper understanding of the problem.

Intelligence is obviously needed in a scientist, but best results are obtained when this is backed by the right sort of motivation and hard work. A man might be impelled by love of his subject, by the desire to gain the respect of his peers, or merely by personal ambition. Whatever the motivation, enthusiasm for the work is needed.

A scientist is required to communicate with fellow-workers, both verbally and in writing. There are far too many, alas, who are unable to express themselves adequately–who make ambiguous statements, confuse the reader and shroud their conclusions in distracting detail. A scientist may be untidy in personal habits, but should never be untidy in his logic.

Perhaps by now it has become clear that research–at least in my field–must be a team effort. Scientists, engineers and technicians with widely different skills and backgrounds are needed to plan the experiment, organize activities, develop, test and calibrate equipment, gather data, analyse the records, study and explain the results, perhaps produce a mathematical model of the ocean, worry about why the theory and experiments do not match exactly, and then plan the next experiment. It is an endless loop, frequently tedious, painful, exacting and arduous, but occasionally exciting when things work out well and interesting answers are obtained. And gradually, by slow degrees, the state of knowledge is increased.

J P BECK, SOUTH AUSTRALIAN POLICE FORENSIC SCIENCE LABORATORY

FORENSIC SCIENCE

Constable Beck first joined the Police Force about ten years ago as a trainee cadet. He soon became a uniformed constable, and was a member of the first breathalyser squad in this state. Next he was promoted to the Criminal Investigation Branch, and from there transferred to the Forensic Science laboratory. As qualification for this position he has received a Science Technician Certificate in Forensic Science from the South Australian Institute of Technology. He is currently attached to the ballistics section of the Forensic Science laboratory.

The *Concise Oxford Dictionary* describes the word 'forensic' as 'of or used in courts of law'. Thus 'forensic science' could be defined as 'the application of science in courts of law'.

In the criminal courts the responsibility for the presentation of scientific evidence for the prosecution usually lies with the Forensic Science Laboratory attached to the Criminal Investigation Branch at Police Headquarters, Adelaide.

The Police Forensic Science Laboratory is staffed by police officers, each of whom has had previous experience in both uniform and plain clothes duties. The present prerequisites in appointment to the staff of the laboratory are, first, sufficient educational qualifications to enable the member to undertake a Science Technicians Certificate Course at the South Australian Institute of Technology, and, secondly, an interest in the application of science to criminal investigations. At the time of writing the staff of the laboratory is eight police officers, with two female auxiliaries to act as typiste-clerks and laboratory assistants.

The application of forensic science could involve any known scientific field. For this reason it is virtually impossible for any one person to become fully competent to give expert evidence on all aspects of forensic science. The South Australian Police Laboratory endeavours to obtain the services of the most highly qualified expert available to make examinations and give evidence on a particular exhibit. To this end work for the Police Department is undertaken by experts from such institutions as the Government Department of Chemistry, the Australian Mineral Development Laboratories, the Institute of Medical and Veterinary Science Laboratories at the Royal Adelaide Hospital, the Red Cross Blood Centre, the Botanic Gardens, the University of Adelaide and the South Australian Institute of Technology.

There are certain fields in which there is no expert available outside the Police Department. These fields include ballistics, document and handwriting examinations, and the comparisons of shoe sole impressions, tool marks and tyre tracks. It is therefore necessary for officers in the Police Forensic Science Laboratory to qualify as experts in one or more of these subjects, a process which takes some four years of constant practice and experience.

Whenever possible a Forensic Science Laboratory officer attends the scene of the crime, where he makes a suitable examination and collects any physical evidence which he considers may have scientific value

the deliberations of the court as to the guilt or innocence of an accused person. As well as making crime scene examinations he also searches for scientific evidence on the clothing of or in the home, vehicle or other possessions of a suspect.

It is of prime importance for the forensic scientist to maintain at all times a strict control of the exhibits which he collects in order to prevent any possibility of contamination, as failure to take such precautions could result in the discarding of any scientific conclusions drawn from the examination of that material. Standardized procedures are adopted throughout the laboratory, and only uncontaminated containers are used to prevent any suggestion of contamination.

Once the physical evidence has been collected it is subjected to preliminary examination in the police laboratory, both for assessment as to its possible value and for deciding upon the appropriate expert to carry out the necessary investigation.

The exhibit is then handed to the expert, with particular attention being paid to maintaining a continuity of possession. This ensures that the exhibit is at all times carefully handled and the evidence is neither lost nor contaminated.

In making his examination the expert is usually required either to *identify* the exhibit as having a particular origin or to *compare* two exhibits and establish whether they are of a common origin.

For some of the experts who undertake work for the Police Department the staff of the Police Forensic Science Laboratory act as laboratory technicians in the preparation of samples for analysis or examination.

To summarize, the duties of the police officers employed in the Police Forensic Science Laboratory involve working as crime-scene examiners, laboratory technicians, liaison officers and experts in their own right in certain scientific fields.

As indicated previously the scope of the types of evidence handled by the police laboratory is almost unlimited, and would be impossible to cover in its entirety in a paper such as this. I have therefore chosen to discuss some of the most common types of evidence, both in relation to their respective value and also with regard to the technique used in their examination.

Paint

This is one of the more common substances submitted for examination, and regularly provides valuable comparisons in investigations into such offences as breakings and hit-run accidents. The samples which are collected or received can consist of several-layered chips of paint, or a smear of a single colour and type. Each can be analysed by use of such instruments as a spectrograph or an electron probe micro-analyser. These instruments give a qualitative and quantitative analysis of the major, minor and trace elements, and it is these latter which provide valuable matches. On occasions it is possible to rely entirely on microscopic matches of multi-layered chips of paint. If enough layers in two chips match in colour, consistency and thickness the mathematical probability of the two having different sources is so remote that it can be disregarded.

Glass

On occasions it has been possible to match broken pieces of glass together by matching the fracture lines. This type of evidence, especially when presented photographically, has been found to be particularly effective, as even a person untrained in scientific fields has no trouble in ascertaining that the two pieces of glass had a common origin. When this type of matching is not possible glass is compared by either physical or chemical tests. The specific gravities and refractive indices can be compared, or the samples can be analysed by use of the spectrograph.

Soil

Soil samples are often present on shoes, clothing and vehicles and even under fingernails. When examined microscopically by geologists samples of soil can provide valuable clues as to their origin. To this end a thorough knowledge of types of soil and their localities is vital. Associated with this type of evidence is such material as dust, sand and safe packing.

Vegetation

As with soil vegetation is found on shoes, clothing, vehicles and similar articles, and can be identified as having come from a particular locality. Owing to the microscopic nature of many of the samples of vegetation located the expert dealing with botanical evidence often relies on cellular structure to make his identification. His knowledge of plant ecology enables him to associate many of the different types of vegetation he finds when making his examination.

Blood

Dry bloodstains, as well as whole blood, can be identified as to the type of animal, human or otherwise, from which it comes. In addition bloodstains can be identified in terms of their A, B or O blood groups. Serological techniques are used to carry out these tests, and can be extended to include other body fluids which contain blood type antigens, for example, saliva, perspiration and semen. Blood grouping is obviously not particularly specific evidence, but can be of assistance in some investigations. The position and shape of splashes or spots of blood can also be of assistance in reconstruction of events at crime scenes, as the direction of travel can be determined from the shape of a spot of blood.

Hair and Fibres

Hair and fibres are examined and identified

microscopically. In addition fibres can be chemically analysed and hair can be examined for scale pattern by making a cast on a microscope slide using clear lacquer. Human hair has been found to contain blood group material in the medulla, and can sometimes be tested to establish the blood group of the person.

Microscopic comparisons of hairs and fibres establish physical similarities, but this type of matching is not specific without additional matching.

Recently hair comparisons have been carried out using the relatively new and particularly sensitive neutron activation analysis techniques.

Seminal Stains

Seminal stains are identified by placing an extraction of the suspect stain on a microscope slide and examining it under high powered magnification to establish the presence of spermatozoa cells. As mentioned previously such stains can often be tested to establish the blood group of the man from whom they came.

The presence of these stains is important, often as corroborative evidence, in such cases as rape and indecent assault.

Shoe Sole Impressions

Shoe soles contain many points of positive identification, and impressions made by soles at scenes of crime on shiny surfaces or in dust or mud can be matched to the shoes responsible for them. Comparisons of shoe sole impressions are illustrated by preparing photographic charts including either an indication of points of similarity or a transparent overlay to provide a comparison of the size and shape of the shoe sole pattern. These impressions are most commonly found at scenes of breakings, but have also provided valuable evidence in investigations into other types of crimes by establishing a circumstantial case that a person was present at a particular locality.

Tool marks

Like shoe sole impressions tool marks are most commonly found at the point of entry at scenes of breakings. The range of implements which can leave distinctive and identifiable marks is very wide and includes screwdrivers, jemmy-bars, bolt-cutters, pliers, tin-snips and even axes and bottle openers. Such implements leave either impressions or scrape marks on surfaces onto which they are forced, and either type of mark can be matched back to the article responsible.

Ballistics

Closely allied to toolmark comparison is the field of ballistics comparison. Distinctive markings are left on both bullets and cartridge cases by the weapon from which they are fired. Grooves on the inside of the barrel of a rifle or pistol—designed to impart a stabilizing spin to the bullet—leave identifying striation marks on the surface of the bullet as it is fired. In addition the firing pin, extractor, ejector, breech block and magazine can all be responsible for identifying marks on the surface of the cartridge case. Even if the weapon used in a particular crime is not available for comparison purposes the ballistics expert is often able to nominate the make and model of firearm used after examining the bullet or the cartridge case.

The ballistics expert is also competent in carrying out safety tests on firearms, and can give opinions on the range of shots and associated details by examining wounds or damage caused by such weapons.

Document Examination

Document examination involves the comparison of handwriting, typewriting, inks and paper and the identification of forgeries, overwriting, impressions in paper and other matters involving documents used in the commission of crimes. Conclusive evidence on all of these matters is possible provided that the material submitted for examination is suitable.

Extra Services Provided by the Forensic Science Laboratory

As well as being responsible for the types of court evidence described previously our laboratory provides assistance to police officers in such matters as training in use of firearms, the preparation of composite photographs of suspects from witnesses' descriptions, the preparation of plans of crime scenes, and the disposal of surrendered and confiscated firearms and explosives.

Forensic Science Outside the Police Department

From my paper you will see that there are many scientists outside the Police Department who not only undertake work in forensic fields but who also have a strong personal interest in this subject. In addition other scientists and people from the legal profession find it both interesting and advantageous to maintain a knowledge of the latest developments in forensic science. To this end a group of these people have formed a South Australian Branch of the Forensic Science Society which is open to scientists, lawyers and police officers. Moves are currently being made to make this organization an Australia-wide one.

Past Cases

Forensic science has been instrumental in the investigation of crimes and in the presentation of court cases in South Australia. Some of the more serious of these cases are the murders which have occurred at Trig Beach, Matheson's Bore, Royal Park and the Exeter Hotel in Rundle Street. While these cases have received much publicity they have been far outnumbered by the many less serious cases in which forensic science has provided an important but unpublicized link in the chain of evidence.

C THIELE, PRINCIPAL, WATTLE PARK TEACHERS COLLEGE

SCIENCE AND CULTURE

After teaching in several high schools Colin Thiele, a graduate and prizeman of the University of Adelaide, became a teachers college lecturer in 1957, and is now Principal of Wattle Park Teachers College.

Mr Thiele is a novelist, playwright and poet of considerable note. *Burke and Wills*, *Edge of Ice*, *The Shark Fishers* **and** *Edward John Eyre* **are some of his more popular plays, while novels which he has written include** *Storm Boy*, *Sun on the Stubble*, *Labourers in the Vineyard* **and a biography of Sir Hans Heysen.**

The assignment I have been given today is to speak briefly – mercifully briefly – on the topic 'Science and Culture'. This disturbs me because I am in some doubt about what the words mean. Each seems to be like the boarding-house dish we used to call 'enthusiastic stew': the landlady put everything she had into it. There is earth science, natural science, medical science, Christian Science and neo-science. There is mental science, social science and political science. There is the Dismal Science (which students lead me to think may be physics) and Absolute Science. There are 'The Seven Liberal Sciences' which, remarkably, are Grammar, Logic, Rhetoric, Arithmetic, Geometry, Astronomy and Music. And, more recently, there is a Pandora's Box of hybrid titles yoked together and released upon the world like flying catamarans: bio-chemistry and astro-physics, quantum mechanics and micro-biology, radio-astronomy and human genetics. Till, finally, I am in danger of ending up with nescience. And that is ignorance.

It is the same with Culture. Geographers alone have three meanings for it. A smog of it – shot through with earrings and cocktail-shakers – hangs over Adelaide at Festival time. The Germans dress it in national passion and spell it with a 'K', the Japanese grow pearls with it, and the Chinese use it for revolutions. Even the young have it now in the form of 'Pop Culture' – which has nothing to do with rice bubbles as it had in my own youth. But in all this there is little illumination. So in the end, if I must use these two terms I'm not sure that I know what I'm talking about – a situation which some people will no doubt agree has persisted for years.

In many ways the problem is linked with the so-called 'Knowledge Explosion', which in recent times has become a super-nova blast. A rain of new fragments has descended on us from a million specializations. And – if I can change the metaphor suddenly from the sublime of the Mysterious Universe to the ridiculous of Australian Rules Football – the eager technologists have learnt to wait around the fringes where the scientific 'big men' fly – to 'shark the crumbs', as they say, and turn them to advantage. To some extent the same has been true of the arts, where new discoveries and technologies have led to passionate experiment and change, innovation on innovation, vogue on vogue, until unhappily the genuine struggle of the creative imagination has often given way to fadism and gimmickry.

In this teeming world of knowledge and experience, of struggle, discovery and adaptation, it is therefore hard to see 'science' and 'culture' as simple, meaningful units. There is grave danger, too, that in assigning our meanings to them we judge only from what we know – and I have already indicated that there is now far too much for us to know, for us ever to hope to know anything but the merest fraction in one lifetime. The relevance of our own bits of experience has become as crucial – and as limiting – as the blindfolded gropings of the characters in the old fable who thought that the elephant was in turn a sapling, a limb or a tree-trunk as their fingers touched tail, trunk or leg. In an age of galloping specialization we tend to touch knowledge in fewer and fewer places. The elephant, meanwhile, is getting bigger and bigger, faster and faster. He seems to be growing more and more legs, tails, trunks, ears and tusks. Touching him in a few places merely makes the task of recognizing and understanding the whole harder and harder. Worse, we have comparatively little choice about the places we touch, especially when we are young. Others lead us and select the spots for us – our education system, school policy, parents' wishes, teachers, peers, disc-jockeys, salesmen, advertisers and touts.

And so, for all these reasons, I think I am really speaking about Civilization and some of its ingredients; about civilization and mankind – today.

For man is an entity, and science and art both contribute – or should contribute – to the things that civilize him. His restless curiosity works equally in the fields both of the sciences and of the arts. The discovery of great natural truths – the revelations of 'natural science' as we would once have said – stirs man spiritually and excites his creative vision in painting, sculpture, music, poetry, drama, philosophy – as many of his finest achievements clearly reveal. We have only to read and see how modern artists and writers have responded to scientific discovery to see that. Even among contemporary Australians there is evidence enough: Douglas Stewart wrestling with Rutherford's wrestling as he probed the nature of the atom and pondered the consequences of his discoveries; or Rosemary Dobson, as a young mother, looking out at a world that Rutherford's science has changed forever, and trembling for her newly-born child:

I see the wounded moon, I fear
The travelling star, the mushroom cloud,
Beneath the perilous universe
For you, for you, my head is bowed.

The miraculous universe that so excites the poet and that lures on the restless curiosity of the scientist also stirs the imagination of the visual artist. In the twentieth century he is tending to link his work more and more closely with the themes, and even the exact forms, of science: the 'divine arithmetic' – as the poet puts it – of the atomic nucleus, the beauty of crystallic forms, the precision of electronic patterns, the visual by-products – so to speak – of physics and chemistry, of optical technology, of structural design in natural phenomena. One of the leaders in this field is a South Australian – Stan Ostoja-Kotkowski – whose recent work with electronic patterns and laser images has been widely publicized.

The extent to which this trend has penetrated many aspects of the arts can be seen in the use of the Moog Synthesizer and other electronic devices in modern music; and in modern art it constantly emerges in the repetitive sequences created by changing light, endless springs engaged in mathematical contortions, forms driven by electric motors, inflating plastic, steel coils, molten glass. And, at a further extreme still, we have conceptual art, where the product remains in the artist's mind and the conception alone is its own justification. In this context mathematics must surely become high art – spare, pure and beautiful.

While these examples reveal how far science, art and technology have tended to come together in the work of many artists, they also hint at the lack of distinction between science and technology in many people's minds. This is certainly so among the public at large, where the scientist and technologist are usually lumped together – a tendency that has rather damaged the image of science as the problems of a technological society have begun to fall on the world. Over-population, pollution of seas, lakes, soil and air, destruction of natural resources, environmental desecration – all have encroached on man's sense of security and well-being. As they have done so he has begun to look for a scapegoat – and the culprit is seen to be the scientist.

This is sad, because the real *malaise* that has afflicted man – and Western man particularly – has little to do with the supply of creature comforts. The standard of living, as we call it, is not necessarily related to the quality of life; or, better, the quality of life is not a function of a material standard of living. For this is a thing of the spirit. It is concerned with the imagination, with convictions, with vision and understanding, with compassion, with the human heart. And this, I fear, is what modern man has largely lost – or, at any rate, is in danger of losing. There are many reasons for it, not least of which is what J B Priestley calls 'Massism' – the vast, impersonal juggernauting of huge societies, the megalopolises of steel and concrete, the mass-fed, mass-entertained, mass-educated, mass-medicated, mass-documented hordes in which individuals become ciphers and human dignity is lost. In such a situation quality disappears, and each unit is subjugated to 'the lowest common denominator of public taste'. In such a society, where things are made for sale rather than for use, the real worth of science is in grave danger of being seduced to baser purposes, as is literature, art and music; hence the pressure on the scientist to take issue with the great moral questions of the day. At present, as I have said, he has come to be seen as responsible – in part at least – for the dilemmas that face mankind. He is therefore to be compelled to help carry the burden of his own making. But he is also seen to provide – or to be capable of providing – solutions to the great dilemmas that menace life, that threaten even existence itself. And so he is still to some extent a source of hope and refuge from the black moon, the mushroom cloud, the subtle enemies who march in legions down the secret roads of nerves and arteries.

If the high expectations that marked the Age of Reason are to be recaptured, if the reputation of the scientist and of scientific method are to be restored in the public mind, then this renewed confidence will depend very much on what happens in the coming decade. The picture of the scientist as a pure and lofty thinker may always have been something of a cliche, but it was certainly linked with a belief in scientific altruism, in pursuit of truth for its own sake, in a sense of service to fixed ideals. Today such a position has little hope of credibility. Idealism is under assault – sent up, ridiculed, satirized, laughed out of countenance. The disillusionment has been accentuated by factors

which have nothing to do with the scientist – political decisions, errors of judgement, greed for profit, mass technology. Even medical science, so long placed on a kind of Hyppocratean pinnacle, has besmirched its image with its monumental blunders over untried drugs, the thalidomide horror and public wrangling over costs and services. Coupled to that are the doubts and fears raised by organ transplants, brain surgery and the perilous fiddlings of geneticists and biologists which threaten to remake man himself. Small wonder that the old picture of the mad scientist secretly creating Frankenstein is reasserting itself. And the super technologies that are docketing and ticketing man – the computerized dossier, the sophisticated snoopery of eye-in-the-sky and bug-in-the-bedroom – stripping him of his privacy, assaulting the last bastions of his individual freedoms; these have brought us to the grim punchline: '1984 – 13 years to go, and counting'. Many are beginning to fear that we will beat Orwell to the deadline.

Yet it is palpably clear that so much of the world's human catastrophe and confusion springs not from natural phenomena or scientific exposition of their properties, or technological innovation in their use. It originates from man's organization, in the kinds of conditions and relationships and pressures that he sets up; in his social order; in his rapport with, or exploitation of, his fellow man; in the standards (another outmoded word) that he adheres to. Or, as Tolstoy put it, 'the things he lives by'.

Those of you who may have heard Allan Ashbolt's address at the Mass Media Congress in Sydney last May, or who have read Henry Schoenheimer's commentary on it, will remember the grim picture he gave. Coupled with the indisputable facts and statistics of today's commercial empires it made more than sombre reading: the Columbia Broadcasting System taking over the publishing firm of Holt, Rinehart and Winston for $280 million; four vast corporations dominating the United States media, and their international empires spanning the planet and even going outside it. Soon there will be international corporations with greater economic power than whole nations.

Physically all this is terrifying enough, but culturally it threatens catastrophe. What is at stake now, as Ashbolt put it, is 'the corrosion of the literary and artistic and historical consciousness of the whole of mankind'. For the principles on which these Krakens of mass control exist are economic; they may have no real concern for cultural issues. The new super-masses they seek to shape are economic units, markets, sales-graphs, purchasing digits; and the output of the giants is therefore not aimed at artistic excellence or even the development of what is human in humanity, but at passivity, acceptance, somnolence. The aim is 'Man as Thing', not man as human being 'engaged in the Great Dialogue'. Who controls these ultimate super-giants bids fair to control mankind. That is the real issue when we talk about culture today. That, it seems to me, is one of the great issues when we talk about civilization and the future of man.

In the twentieth century we have lost sight of the great humanistic tradition. The scientist as natural historian and poet, the vision of one man as explorer of one world, the concept of life as total unity – these have wavered and faded. Fragmentation, as I have said, is everywhere, and as the years grind on the fragments get smaller and smaller. Now they are beginning to have the taste of dust. Yet this is unnatural – as unnatural as the mass-production line to the craftsman, as massism to individuality, as the alienation of the individual student in the vast ant-heaps of today where he feels the pressures so great that taking a degree is 'like trying to drink at a fire-hose'. We grope for a guiding principle; religion discredited, ethics and morality fallen, humility forgotten, education faltering in purpose. In desperation we put mankind and his actions into categories and convince ourselves that this helps to solve our problems. Instead of blaming economic greed we blame science.

It is all futile and sad – and unnecessary. For the scientist has been, and can be, philosopher; as the poet is philosopher; as the artist is poet and the composer artist. In the end all seek the same goal – discovery, revelation, the nature and purpose of life, the meaning of man. In that context Science and the arts, science and culture – if we must finally come to use these terms – stand side by side. Culture subsumes science. Both rest wholly in man. Both serve to civilize.

The things that make for civilization may be hard to express, but basically they are clear and simple. They have been present so often in the world's history, even amidst turbulent times; just as they have been absent often enough in seemingly propitious times. Just as there is so much all around us that is uncivilizing today.

Civilization grows on creative energy, on the search for excellence, on the drive to explore and express, to grasp an ideal, to understand. It dies in a climate of apathy, exhaustion, cynicism, hatred, fear, barbarity. From time to time, as Sir Kenneth Clark has recently pointed out, man has lifted himself suddenly and strikingly in just such a surge of energy and belief and conviction. And when that happens it is absurd to suggest that science and the arts are not both equally a part of it.

At the very end of his book, *Civilization*, and of his celebrated television series, Clark attempted to sum up, to see the point where he was standing in relation to the vast sweep of man's history and achievement that lay behind him:

It is lack of confidence more than anything else that kills a civilization. We can destroy ourselves by cynicism and disillusion just as effectively as by bombs. Fifty years ago W B Yeats, who was more like a man of genius than anyone I have ever known, wrote a famous prophetic poem.

'Things fall apart; the centre cannot hold;
Mere anarchy is loosed upon the world,
The blood-dimmed tide is loosed, and everywhere
The ceremony of innocence is drowned;
The best lack all convictions, while the worst
Are full of passionate intensity.'

Well, that was certainly true between the wars, and it nearly destroyed us. Is it true today?

Sir Kenneth Clark is cautiously hopeful, but admits that it is hard to be optimistic. Can we afford to be? There may still be time, but it seems to be running out. The crux may well lie with the world's teachers – and that is a sober thought to raise at a conference such as this. Yet I am convinced that it is agonisingly relevant. The spirit of inquiry, of active involvement, of energy in making and doing depends largely on teachers for awakening or for revitalization. Teachers, moreover, who see life as unity – science, humanities, fine arts, all of these. Without them I don't think we are likely to leave behind us that zest for quality of life which builds great civilizations.

You may remember Petulengro, in George Borrow's portrait of the Romany Rye, who found it inconceivable that life should not be worth living: 'There's the wind on the heath, brother; there's the sun and the moon and the stars, brother; all sweet things'.

It is the Petulengro in us that one hopes can always survive; that quality of joy in life which ennobles and civilizes man and lifts up his heart. Albert Schweitzer was looking at it the other way round when he said, 'The tragedy of life is what dies inside a man while he lives'.

At a conference such as this I think none of us could fail to recognize the force of Schweitzer's point. Whether we are scientists or artists we cannot afford to let whatever we have of that spirit die inside us while we are still alive.

HERE'S HOW I DO IT . . .

PROJECTION TECHNIQUES

M Silis, Underdale High School

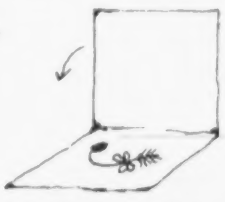
Maris Silis

35mm 'Slides' of Biological Specimens

Suitable specimens, when sandwiched between the two halves of a folded piece of acetate and mounted, can be projected with an ordinary 35mm slide projector.

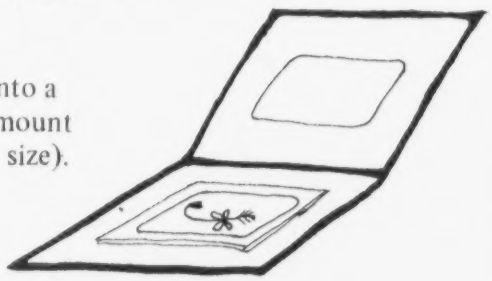
Procedure

1 Fold in half a 3½" x 1¾" piece of clear cellulose acetate.



2 Place the specimen in the middle of one half.

3 Insert this unit into a cardboard slide mount (standard 35mm size).



5 Label, if necessary, using a fine mapping pen and Indian ink.

Suitable specimens

1 Mosses:
Illustrate life cycle and diversity.

2 Fungi:
For example, bread mould.

3 'Spore prints':
Cut the 'head' off a small mushroom and place it on the acetate sheet; leave overnight.

4 Feathers:
Compare flight and down feathers.

5 Cross-struts in wing bones of birds:
Cut a thin, longitudinal slice of boiled wing bone. Carefully clean out the meat and mount.

6 Veins in leaves:
Use decayed leaves.

7 Insects:
The 'crane-fly' which resembles a large mosquito is very suitable.

Suggested method of use

While the teacher can make and use these slides I have found that students are very keen to project to the rest of the class and to talk about slides which they themselves have made. As well as being extremely motivating this helps to develop skills in communication, an important aspect of our science teaching.

Hand-drawn 35mm Slides

Hand-drawn diagrams, graphs and tables can easily be made into 35mm slide transparencies without using a camera. 'Super' slides are preferable because they provide a larger area for projection. Hand-drawn slides can be stored and used in sequence with normal 35mm photographic slides.

Procedure

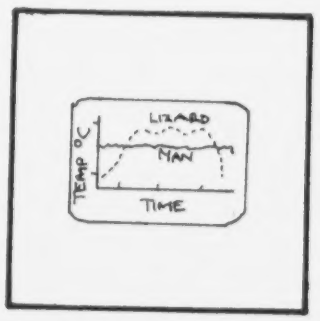
1 Divide a quarto sheet of smooth white paper into 1¾" x 1¾" squares.

2 Within each square draw the diagram using a fine mapping pen and Indian ink.

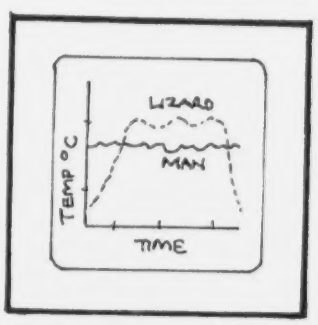
3 Make a transparent copy of the completed sheet using a heat copying machine.

4 Cut out the squares of the transparencies and mount each one in a self-adhesive 'Super' mount (available from photographic suppliers). Cardboard mounts are suitable.

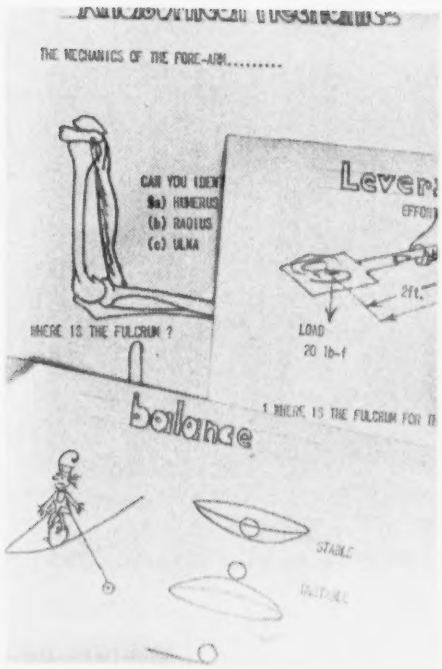
5 If necessary add colour with fine-tipped overhead projector transparency pens.

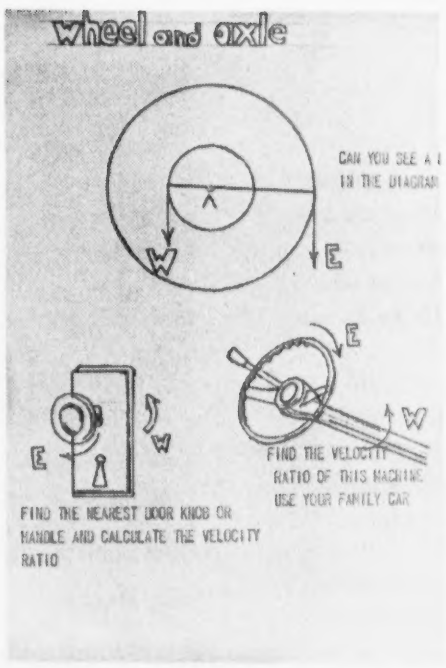


Standard size 35mm slide mount



'Super' size 35mm slide mount




wheel and axle
W
E
FIND THE NEAREST DOOR KNOB OR HANDLE AND CALCULATE THE VELOCITY RATIO
FIND THE VELOCITY RATIO OF THIS MACHINE USE YOUR FAMILY CAR

SOMETHING OLD, NOTHING NEW AND EVERYTHING BORROWED

E Nunan, Salisbury East High School

Teaching the topic 'Machines' to a bunch of third year students is hardly something to get 'steamed' up about; one almost has to 'lever' oneself into the task. 'Something old and nothing new' would probably be the way we might describe the task to a fellow science teacher. The topic has been taught for years without any revolutionary changes in subject matter.

But now add a third element, 'everything borrowed', to the other two, place them in a laboratory and 'spillover' area such as a corridor, stir and shake well and – hey, presto – individual progression!

Of course a lot depends on what you can 'borrow' materials like 35mm slides, transparencies, books and charts. Some of these materials you can make for yourself to suit your own teaching; for example, a set of 35mm colour slides on machines in the home (simple things such as bottle openers, scissors, door handles and the like), or a set of projection transparencies on levers in the body.

These visual materials are essential to the individual progression style of teaching. They can be used outside the laboratory, thus freeing the lab for a variety of additional activities. They can also be used to 'control' the group as a whole, with the faster students doing more of these extension activities so that the slower students can spend more time on the basic material.

In the overall plan of the work presented to the students it is desirable to have a means of checking the progress of the student and a means of finding out which activities the student has completed.

The plan that I have used is tabulated below. Any flow chart of these activities will, of course, depend on what is available in the way of resources, apparatus and time.

Topic	Experiments	Extension Materials	Test
Machines	*Discovery in Science*, Bk 3, Expt 59	**Perpetual motion** OHP and reading assignment	
		Conservation of Energy Slides and tape	
Levers	*Discovery in Science*, Bk 3, Expt 60	**Levers in the home** Slides and tape	mini-tests
		Levers in the body OHP instruction and questions	
		Balance Reading and experiment	
Wheel and axle	*Discovery in Science*, Bk 3, Expt 64		mini-test
Inclined planes	*Discovery in Science*, Bk 3, Expt 63	**Double inclined plane** OHP and questions	mini-test
	In Search of Science, Bk 3	**Cams** OHP and questions	
Pulleys	*Discovery in Science*, Bk 3, Expt 62	**Types and uses of pulley systems** Slides and tape	mini-test
Gears	*Discovery in Science*, Bk 3, Expt 65	**The bicycle** *In Search of Science*, Bk 3	
Review			major test using OHP

FLUID DYNAMICS

T Woolley, Maitland Area School

The need for students to be able to follow streamlines around differently shaped objects accurately poses a problem for demonstration and individual practical lessons. In the majority of cases it is much easier to move the object through the fluid than to move a coloured fluid past a stationary object.

This effect can be seen very clearly and demonstrated with considerable impact using an overhead projector, a ripple tank and a Harrison Optical Kit. The method for producing streamline effects can be easily adapted for student activity, and a good deal of 'extension experimentation' is possible.

The ripple tank is placed on the overhead projector and about ¼" of water added. The critical step is to add a fine sprinkle of potassium permanganate crystals to the water. (Practice will show the correct amount needed.)

The optical kits offer a variety of transparent prisms and lenses which can be used to investigate streamlines by pushing them slowly through the water which is coloured with streams of the purple potassium permanganate solution. The lines of flow around the different shapes are projected in colour onto a screen.

Some points to consider

1 The depth of the water should be slightly less than the optical shape.

2 Use fine crystals; sprinkle them evenly and sparsely.

3 Apply pressure on the back and top of the shape with the thumb and forefinger.

4 Push *slowly* for maximum effect.

5 As the permanganate may stain the prisms wash them thoroughly after use or see the chemistry teacher for a method of removing permanganate stains.

For further extending this technique I used special shapes cut from ¼" perspex. (If your school has a plastics course in the craft section it would be most helpful.)

With suitable shapes one can demonstrate streamlines around:

Spheres:

Terminal velocity and 'sound barrier' factors are seen clearly from this.

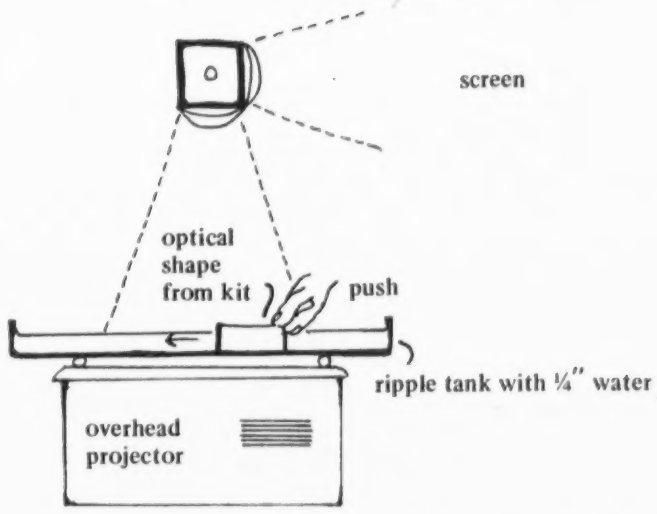
Bernoulli effects on spinning spheres can also be noted.

Aerofoil shapes:

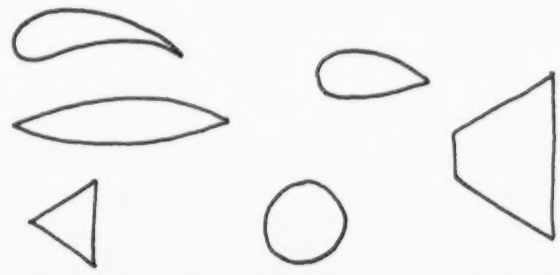
The stall angle is clearly seen.

Aircraft and marine design follow on from such considerations.

Terry Woolley

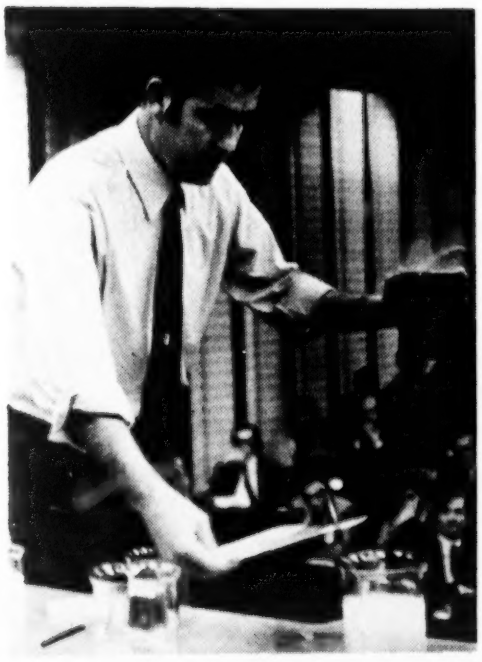


SHAPE SUGGESTIONS

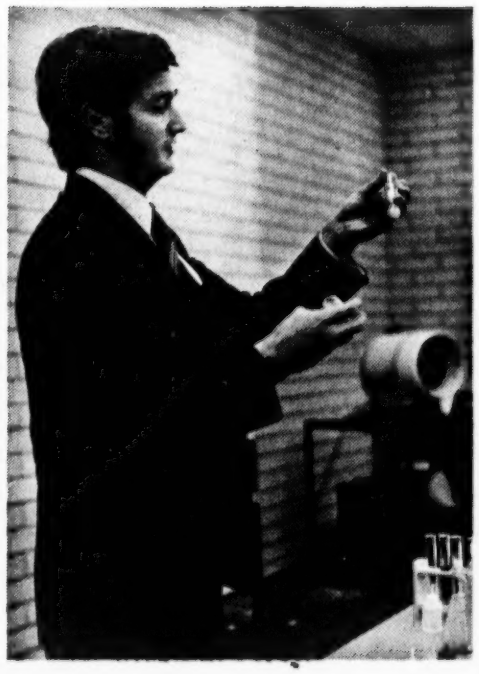


The technique has application in much of the fluid dynamics section of the leaving physics course, and it can be used to stimulate discussion in the following topics:

1 Smooth and turbulent flow.
2 Flow characteristics around different shapes.
3 Turbulence in fluids due to relative object movement.
4 Stall angles and aircraft design.



Bob Morton



Malcolm Lindquist

Dick Arnold

SOME INTERESTING CHEMICAL REACTIONS

R Morton, Port Augusta High School
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Many of the 'big ideas' of chemistry – such as energy changes, reaction rates and the formation of new substances – can be introduced or illustrated with reactions which have considerable visual impact. Here is a representative cross-section of certain such reactions.

You will notice at the end of each heading one or more alphabetical letters. These correspond to one or more of the 'big ideas' which the reaction is designed to illustrate, according to the following key:

A Formation of new substances
B Energy changes
C Reversibility
D Reaction rates
E Stoichiometry
F Catalysis

The Oxidation of Sugar (A, B)

Requirements
sugar (granulated)
potassium chlorate
concentrated sulphuric acid

What to do
Mix thoroughly equal quantities of granulated sugar and potassium chlorate on a tile. (If powdered sugar is used the reaction is likely to be too violent.)
Add 1 drop of concentrated sulphuric acid using a long teat pipette and quickly step back.

What will happen
The mixture ignites spontaneously and burns vigorously with a lilac-tinged flame. Smoke is also produced and a spongy, grey-black, porous solid remains.
In this reasonably complex reaction it is thought that chlorine dioxide (ClO_2) forms. This material is unstable and an extremely strong oxidizing agent:

$$KClO_3 + H_2SO_4 \rightarrow KHSO_4 + HClO_3$$

$$3HClO_3 \rightarrow HClO_4 + H_2O + 2ClO_2$$

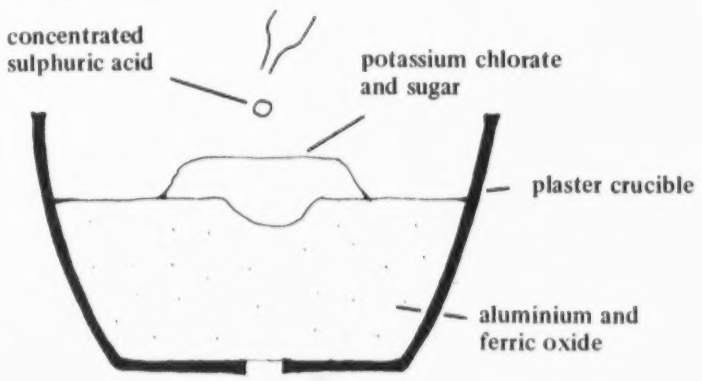
It is misleading to talk of the 'oxidation' of sugar if carbon is considered to be the main organic product. In actual fact the main products of oxidation are carbon monoxide and carbon dioxide, which are evolved as gases.

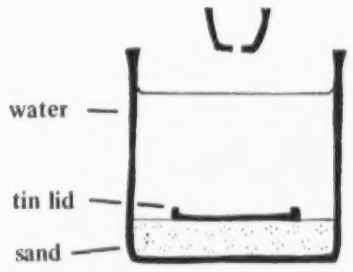
The Thermite Reaction (A, B)

Requirements

home-made plaster crucible with a small hole in the base
aluminium powder
iron oxide (Fe_2O_3)
sugar
potassium chlorate
concentrated sulphuric acid

What to do





Mix equal quantities of aluminium powder and iron oxide.
Place in a plaster crucible together with equal quantities of mixed granulated sugar and potassium chlorate.
Float the crucible on water above a tin lid and sand.
Add 1 drop of concentrated sulphuric acid to start the reaction.

What will happen

The potassium chlorate/sugar mixture will react violently after the addition of the concentrated sulphuric acid, and this reaction will provide enough heat to start the reaction between the aluminium and the iron oxide. This reaction is so exothermic that one of the products, iron, will form as a liquid, and small drops of molten iron will fall though the hole into the water.

$$Fe_2O_3 + Al \rightarrow Fe + Al_2O_3$$

The solidified drops of iron can be collected on the tin lid.

Note

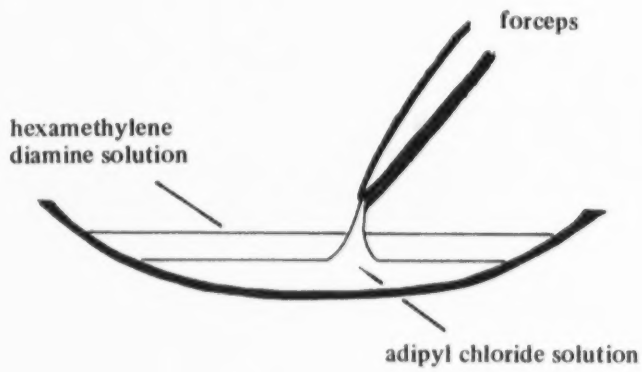
A variation of this reaction is to use a piece of burning magnesium ribbon as a 'starter' for the conversion of the iron oxide to iron.

Making a Nylon Thread (A)

Requirements

5% solution of hexamethylene diamine (1:6 diaminohexane) in 2M sodium hydroxide solution
5% solution of adipyl chloride in cyclohexane
forceps

What to do



Place 1 ml of adipyl chloride solution in a watch glass.
Carefully add 2 ml of hexamethylene diamine solution.
Grip the 'skin' that forms at the interface of the two solutions with a pair of forceps, and slowly draw it out into a thread.

What will happen

At the interface of the two solutions the hexamethylene diamine and adipyl chloride react together and form the polymer nylon. The nylon skin at the interface can be slowly drawn out into a thread as new skins form continuously at the interface.

Note

These solutions will remain stable for several weeks only.

Making Froth (A)

Requirements
solid sodium carbonate
5M hydrochloric acid
detergent

What to do
Mix approximately 10 g of sodium carbonate and detergent in a 1 litre beaker.
Add 200 ml of 5M hydrochloric acid.

What will happen
As carbon dioxide is evolved the detergent will foam until it cascades over the side of the beaker.

The Reaction Between Zinc and Copper Nitrate Solution (A, B)

Requirements
zinc powder
1M copper nitrate solution

What to do
Add two heaped spatulas of zinc powder to 500 ml of 1M copper nitrate solution in a 1 litre beaker.
Stir the mixture well.
Examine the contents of the beaker at the end of the reaction.

What will happen
Brown fumes of nitrogen dioxide are produced. The solution becomes quite hot. Measurement of the increase in temperature will enable the number of calories produced to be calculated.

The Reaction Between Zinc and Copper Nitrate in the Solid State (A, B)

Requirements
fine zinc powder
copper nitrate crystals

What to do
The experiment should be done in a fume cupboard.
Place a small heap of copper nitrate crystals on a lino tile.
Next to this heap place a similar sized heap of zinc powder.
Using a large spatula stir the two heaps into one another.

What will happen
There is a spontaneous evolution of brown fumes of nitrogen dioxide. The reaction is exothermic.

The Reaction Between Zinc and Copper Sulphate Solution (A, B)

Requirements
zinc powder
1M copper sulphate solution

What to do
Add two heaped spatulas of zinc powder to 500 ml of 1M copper sulphate solution in a 1 litre beaker.
Examine the contents of the beaker at the end of the reaction.
Compare the products with those produced in the previous reaction.

What will happen
The solution becomes quite hot. The number of calories produced may be calculated from temperature measurements.

Note
The reaction between these two substances is used to produce electrical energy in a Daniell Cell.

The Reaction Between Magnesium and Dilute Hydrochoric Acid (A, B, D)

Requirements
magnesium ribbon
magnesium powder
2M hydrochloric acid

What to do
Add the magnesium ribbon and powder separately to 2M hydrochloric acid in two 1 litre beakers.

What will happen
The ribbon reacts much more slowly than the powder. There is also a spectacular temperature rise with the magnesium powder.

The Reaction Between Sodium and Copper Sulphate Solution (A, B)

Requirements
sodium
1M copper sulphate solution

What to do
Drop a *small* piece of sodium (less than pea size) into 100 ml of 1M copper sulphate solution in a 250 ml beaker.

What will happen
Enough heat is generated during the reaction to cause sodium to commence burning. Inspection of the contents of the beaker after the reaction reveals several different products.

The Precipitation of Calcium Carbonate Solution (A, B)

Requirements
2M calcium chloride solution
2M potassium carbonate solution

What to do
Mix 400 ml of 2M calcium chloride solution with 400 ml of 2M potassium carbonate solution in a 1 litre beaker.

What will happen
A thick precipitate forms making stirring very difficult. Temperature measurements show that the reaction is endothermic.

Note
This method may be used for the preparation of other insoluble substances.

The Preparation and Ignition of Acetylene and Chlorine (A, B)

Requirements
sodium hypochlorite solution or bleaching powder
2M hydrochloric acid
calcium carbide

What to do
Place several millilitres of sodium hypochlorite solution (or a couple of teaspoons of bleaching powder) in a gas jar.
Add several millilitres of 2M hydrochloric acid and wait for chlorine to be evolved.
Then add a few small, fresh lumps of calcium carbide to the solution.
Cover the gas jar with a piece of cardboard.

What will happen
Both chlorine and acetylene will be produced in close proximity. The gaseous mixture will spontaneously ignite to produce carbon and hydrogen chloride.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

$$ClO^- + 2H^+ + Cl^- \rightarrow Cl_2 + H_2O$$

$$C_2H_2 + Cl_2 \rightarrow 2C + 2HCl$$

A Silicate Garden (A, B)

Requirements

33% sodium silicate solution

crystals containing the following ions.

Fe^{+++}, Pb^{++}, Ag^{+}, Mn^{++}, Cu^{++}, Ni^{++}, Co^{++}, Cr^{+++}

What to do

Thoroughly mix the silicate/water mixture, the SG of which should be approximately 1:1.

For added effect drop powdered samples onto the surface of the solutions.

What will happen

Silicate crystals will appear within 24 hours – some with remarkable rapidity – producing a multi-colour 'silicate garden' that can be used as a display.

Oxidation of Methanol (B, D, F)

Requirements

methanol

platinum wire

What to do

Place 150 ml of methanol in a flask. Shake.

Coil the platinum wire into a loop, heat it to red heat and plunge it into the flask just above the surface of the methanol.

What will happen

The platinum acts as a catalyst in the conversion of methanol to formaldehyde. The reaction is exothermic and gives out sufficient heat to keep the platinum wire glowing. Sufficient heat may be evolved to ignite the methanol.

Colourful Reactions (A, B)

Requirements

solutions of: potassium iodide, copper sulphate, potassium chromate, silver nitrate, lead nitrate, concentrated ammonia

What to do

Reaction 1

Mix potassium iodide and lead nitrate solutions.

Reaction 2

Mix copper sulphate and concentrated ammonia solutions.

Reaction 3

Mix potassium chromate and silver nitrate solutions.

What will happen

A brilliant yellow precipitate of lead iodide forms.

$$Pb^{++} + 2I^{-} \rightarrow PbI_2\downarrow$$

Reaction 2

The intense blue-coloured tetrammine copper complex ion forms.

$$Cu^{++} + 4NH_3 \rightarrow Cu(NH_3)_4^{++}$$

Reaction 3

Red silver chromate precipitates.

$$2Ag^{+} + CrO_4^{=} \rightarrow Ag_2CrO_4\downarrow$$

Sublimation of Iodine by Heat of Solution (B)

Requirements

iodine crystals

solid sodium hydroxide

What to do

Moisten the outside of a large test tube with a little glycerine or water.

Dip the test tube into the iodine crystals until the surface is covered with a layer of iodine.

Place 1" of water in the test tube and add 5 g of sodium hydroxide.

What will happen

The heat evolved as the solid sodium hydroxide dissolves is sufficient to cause the iodine to sublime. Violet vapours will be readily observed.

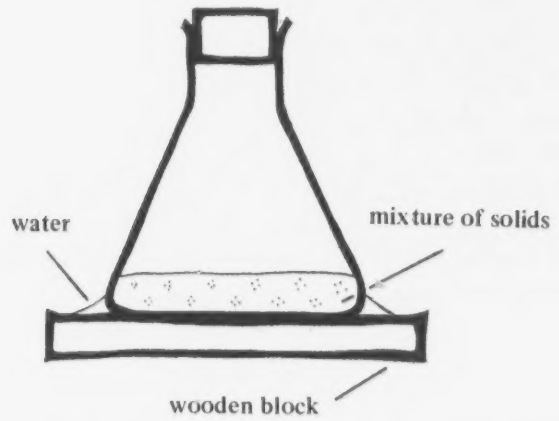
Note

This method could be applied to show the exothermic nature of a large number of suitable test tube reactions.

A Spectacular Endothermic Reaction (A, B)

Requirements
solid barium hydroxide
solid ammonium thiocyanate

What to do



Add 2 parts solid ammonium thiocyanate (NH_4CNS) to 1 part solid barium hydroxide ($Ba(OH)_2.8H_2O$) in a conical flask.
Stopper, shake and place on a wet block of wood as illustrated.

What will happen
The solid mixture becomes wet and bubbles of ammonia form. The reaction is endothermic and water on the wooden base will freeze, causing the block to adhere to the flask. A possible equation for the reactior is:

$$Ba(OH)_2.8H_2O + 2NH_4CNS + \text{heat} \rightarrow Ba(CNS)_2 + 2NH_3 + 10H_2O$$

If the stopper is removed ammonia can be readily detected.

A Study of the Rate of a Reaction Using the Overhead Projector (A, D)

Requirements
1M sodium thiosulphate solution
2M hydrochloric acid
overhead projector

What to do
Stick a small cross (made from adhesive label paper) on the outside base of a 250 ml beaker. When the beaker is then placed on the overhead projector an image of the cross is projected.
Place 100 ml of thiosulphate solution in the beaker.
Add 20 ml of hydrochloric acid.

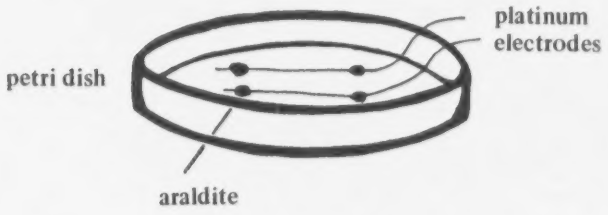
What will happen
A sulphur suspension begins to form as one of the products of the reaction. This suspension eventually reaches sufficient concentration to blanket out the cross on the screen. The time taken for this to occur may be easily measured.

Note
By varying the concentrations of the reactants or the temperature and taking corresponding time measurements the effect of concentration and temperature on the rate of this reaction may also be seen.

Electrolysis of Potassium Iodide Solution Using the Overhead Projector (A, B)

Requirements
potassium iodide solution
electrolysis cell (see diagram)

What to do



Place the cell (see the diagram for details) on the overhead projector and add sufficient potassium iodide solution to cover the electrodes. When the electrodes are correctly focused connect them to a 6V DC supply.

What will happen
The formation of iodine at the anode and hydrogen bubbles at the cathode will be clearly visible.

At the anode: $2I^- \rightarrow I_2 + 2e^-$

At the cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Note
Other electrolysis reactions can be carried out in the same cell; for example, electrolysis of dilute acids, sodium chloride solution, copper sulphate solution etc. pH changes can be followed if several drops of universal indicator are placed near each electrode.

The 'Iodine Clock' (A, D)

Requirements
'iodate' solution:
4 g sodium iodate per litre
'thiosulphate' solution:
1.26 g sodium thiosulphate, 1.47 g concentrated sulphuric acid and fresh starch solution per litre

What to do
Place the following quantities of the two solutions in separate flasks.

FLASK	1A	2A	3A	4A	5A
ml 'thiosulphate' soln	50	50	50	50	50
ml water	175	150	100	50	–
FLASK	**1B**	**2B**	**3B**	**4B**	**5B**
ml 'iodate' soln	25	50	100	150	200

Quickly mix the contents of 1A and 1B, 2A and 2B and so on.

What will happen
A redox reaction occurs, iodine being one of the products. When the iodine concentration reaches a certain point the characteristic deep blue colour of the iodine-starch complex becomes apparent.

$2IO_3^- + 10S_2O_3^{=} + 12H^+ \rightarrow 5S_4O_6^{=} + I_2 + 6H_2O$

The Electrolytic Production of a Hydrogen/Oxygen Mixture and Ignition of the Mixture (A, B, C, D, E)

Requirements
see diagram

What to do

Assemble the apparatus as shown. The screw-lid and the connections must be airtight.

Connect the electrodes to a 6V DC power supply and switch on. Bubbles of hydrogen and oxygen are produced at the electrodes. Some time must be allowed for air to be expelled from the jar if the ignition later on is to produce a 'bang'. A small jar is preferable because less time is then needed to expel the air. The mixture of gases is passed into the detergent solution where bubbles containing the mixture (hydrogen : oxygen = 2:1) will form, provided there is no leaking connection and the end of the tube is not held too far beneath the surface of the detergent solution.

After a few bubbles have formed the tubing is removed well away from the evaporating dish.

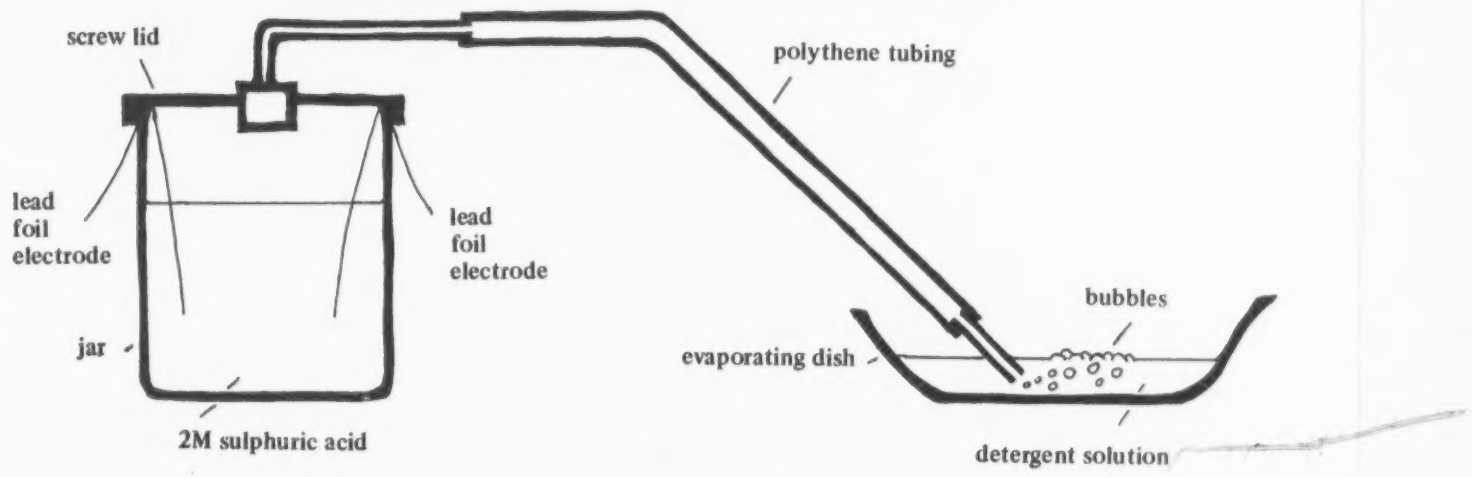
The mixture in the bubbles is then ignited by bringing a lighted taper (about 1 foot length) up to the bubbles.

What will happen

A loud but harmless explosion should result – much louder than when pure hydrogen is used.

Note

After allowing the electrolysis to proceed for about 30 minutes the 6V DC supply can be disconnected and a voltmeter placed across the electrodes. A reading on the voltmeter will be obtained, demonstrating the principle of the lead accumulator.



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